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HDG 08070

December 1998 • $4.50
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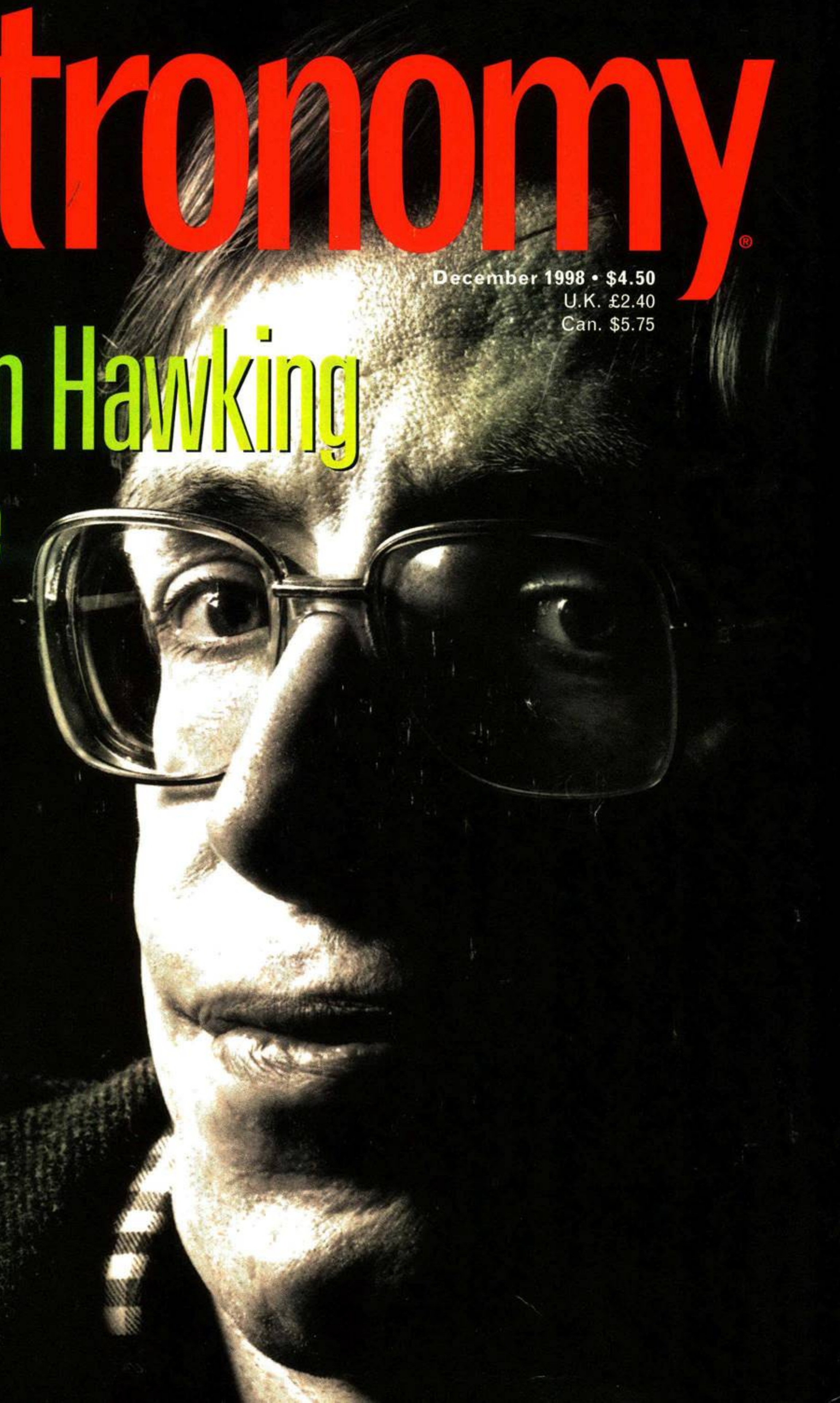

Stephen Hawking

Black Hole Wrangler

Science and Religion Shake Hands

In the *New* Kids' Corner, Holiday Gifts

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MEADE LX50

Advanced technology at the most affordable prices *ever.*

- **Battery-Powered, Completely Cordless Operation!** Meade LX50 models operate for more than 50 hours from six AA-size batteries inserted through the telescope's control panel. Or use the standard-equipment 25 ft. cord to power the telescope directly from any auto cigarette lighter plug.

- **Standard-Equipment Declination Motor and Hand Controller:** Plug the hand controller into the LX50 control panel and you're ready for full dual-axis drive capability at any of 4 photo-guide or microslew speeds: 2x, 8x, 16x, or 32x, plus quartz-controlled sidereal-rate tracking in R.A. Switch speeds instantly using the speed-control button on the hand controller. Dual-axis drive rate is indicated by a red LED.

- **Multi-Function Control Panel:** Includes connectors for CCD autoguiders; for the standard-equipment Declination motor; and for the optional Magellan II Computer-Corrector *(below).* A North-South switch permits telescope operation anywhere in the world.

- **Super Multi-Coated Optics:** The exact same EMC super multi-coated optical tube assemblies included with Meade LX200 models.

- **Massive LX200-type Fork Mounts:** Meade LX50 mounts are manufactured of the same virgin aluminum castings as Meade LX200 Schmidt-Cassegrains. Massive, rigid mountings that include the Meade LX worm-gear drive system with low periodic error for advanced photographic or CCD imaging applications. *No competing mid-priced equatorial mountings even come close.*

SPECIFICATIONS: 7", 8", and 10" LX50's—Each complete telescope includes 8" or 10" f/10 Schmidt-Cassegrain or 7" f/15 Maksutov-Cassegrain optical tube assembly with EMC super multi-coatings; heavy-duty LX200-type fork mount; 5.75" LX worm gear system in R.A.; multi-function control panel; DC servo Declination motor; manual and electric slow-motion controls on both axes; setting circles on both axes; keypad hand controller; 4-speed drive controls on both axes; battery compartment accepting six (user-supplied) AA-size batteries; 25 ft. power cord for telescope operation from 12v. auto cigarette lighter plug; 6 x 30mm (7" and 8" models) or 8 x 50mm (10") viewfinder; 1.25" diagonal prism; Series 4000 Super Plössl 26mm multi-coated eyepiece (1.25"); standard equatorial wedge with elevation scale, bubble level, and azimuth control; complete operating instructions.

Meade Magellan™ II Computer-Corrector for LX50 Telescopes: Plug the Magellan II into the control panel of your LX50 and enjoy an incredible range of advanced capabilities. ■ Fast manual slewing to any object, either from input RA and Dec or from the 12,218-object database. ■ High-resolution 4096-pulse encoders (5.3 arc-minute precision), concealed in special LX50 encoder compartments. ■ Large 32-character, red-backlighted display. ■ Quick 2-star alignment. ■ Four-speed (2x, 8x, 16x, 32x sidereal) dual-axis drive corrector/microslewing system.

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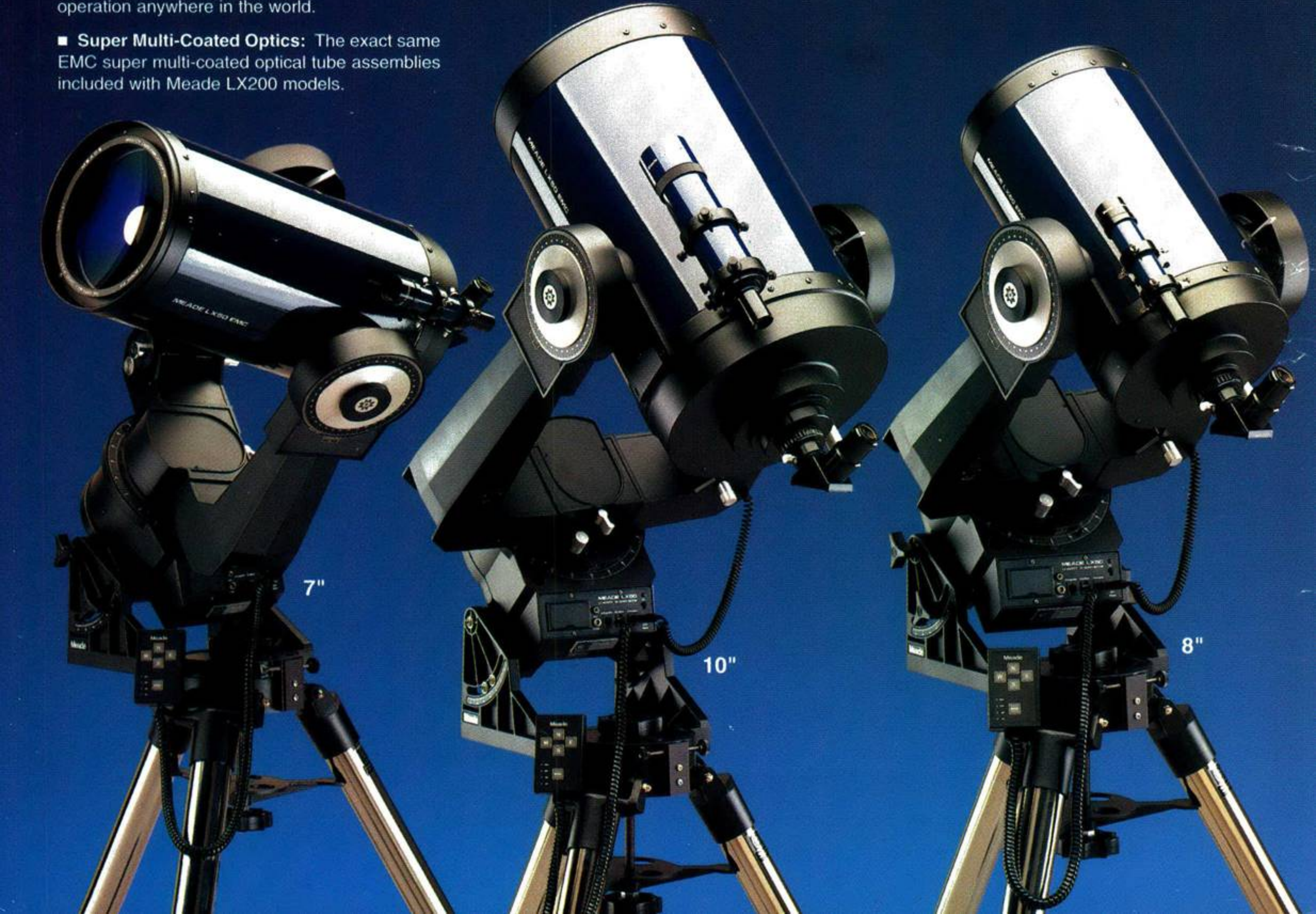
only $495!

#2024: Magellan II for LX50's—Includes Magellan II hand controller *(right)*; encoders for both axes; all required mounting hardware. Installs to any LX50 in minutes. **$495.** + $15 packing and shipping in the 48 states.

8" LX50 Schmidt-Cassegrain	**$1395.**
10" LX50 Schmidt-Cassegrain	**1695.**
7" LX50 Maksutov-Cassegrain	**1795.**
Variable-Height Field Tripod	**295.**
7" Maksutov-Cassegrain Tube Ass'y	**1295.**

Packing and shipping in the 48 states: 8"—$105; 10"—$145; 7"—$125; 7" Tube Assembly—$65.



In virtually every country in the world where serious telescopes are sold, more Meade LX200's are sold than all competing models *combined*. Consider these *standard-equipment* specifications:

- **Superb Optics:** LX200 diffraction-limited imaging capabilities are a legend in the industry; we regularly receive reports stating that optical performance approaches that of a fine *ED* apochromatic lens.
- **Automatic GO TO Capability:** Meade LX200's are *the only commercial telescopes ever manufactured* that automatically GO TO any input R.A. and Dec., or to any of 64,359 objects in the onboard database, *to a precision of one arc-minute or better.*
- **Meade LX200 High-Precision Pointing™** is so precise it permits the positioning of *every* selected object on *every* commercially-available CCD chip *every* time, automatically — *a feat that no other telescope priced under $40,000 can accomplish.*
- **Permanently-Programmable Smart Drive™** routinely achieves 5 arc. sec. periodic error, an observatory standard.
- **9-Speed Dual-Axis Electronics:** Electronics that cover every possible contingency of telescope positioning—from 2x photo-guide, to 32x image centering, to 8°/sec. slewing across the sky, as well as 6 other dual-axis drive speeds in between.
- **Field Operation:** No other telescopes of such incredible capabilities transport so readily for field operation. The optional #1812 Electronic DC Adapter (a compact 4 oz. unit) allows for field powering directly from an automobile cigarette lighter plug.

MEADE LX200

The largest-selling serious telescopes in the world.

SPECIFICATIONS: 7", 8", 10", and 12" LX200's—Each complete telescope includes 8" or 10" (f/6.3 or f/10) or 12" f/10 Schmidt-Cassegrain or 7" f/15 Maksutov-Cassegrain optical tube assembly with EMC super multi-coatings; heavy-duty fork mount with 4" polar ball bearing, dual-axis 5.75" worm gears, and multi-function control panel; manual and electric slow-motion controls on both axes; keypad hand controller with digital readout display, permanently programmable Smart Drive, 9-speed drive controls on both axes (7-speed on 12"), High-Precision Pointing, and GO TO controller; 64,359-object onboard celestial software library; 25 ft. power cord and adapter for telescope operation from 115v.AC; 8 x 50mm viewfinder; 1.25" diagonal prism (7", 8", 10") or 2" diagonal mirror with 1.25" adapter (12"); Series 4000 Super Plössl 26mm eyepiece; standard field tripod (7", 8", 10") or giant field tripod (12"); operating instructions.

8" LX200 Schmidt-Cassegrain	**$2795.**
10" LX200 Schmidt-Cassegrain	**3195.**
12" LX200 Schmidt-Cassegrain	**4495.**
7" LX200 Maksutov-Cassegrain	**3295.**

Packing and shipping in the 48 states: 8"—$105; 10"—$145; 12"—$215; 7"—$125.

MEADE LX200 EMC
8"
7"
10"
12"
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COVER PHOTO: Francis Giacobetti

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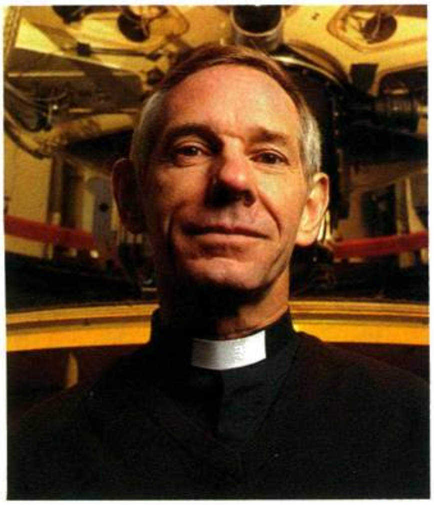

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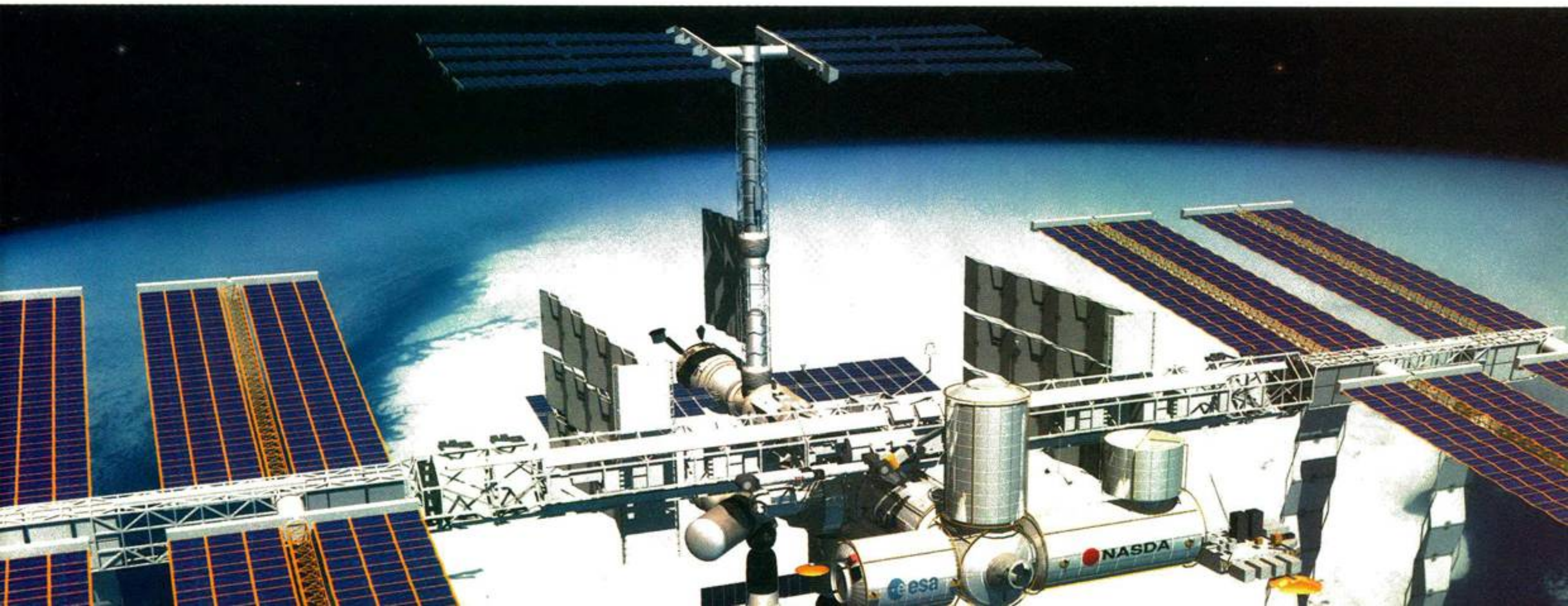


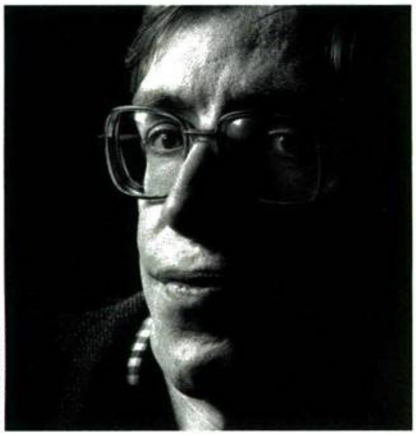
BEHIND THE SCENES

BY BONNIE BILYEU GORDON

Cover Shot

In our 25th anniversary year, we have enjoyed many "firsts." We held our first science forum in January 1998, to which we brought accomplished, creative astronomers, cosmologists, and physicists to help us predict the future. That meeting served as the underpinning for a feature story in our biggest issue ever, our August anniversary issue. In March we produced an unprecedented 3-D issue, and in June we threw our own free public star party in New Mexico.

In the final month of this year-long celebration, we bring you some dazzling stories, stories that are core to your understanding of astronomy and our mission to expand that understanding. For us, *Science* magazine writer Andrew Lawler, who covers NASA regularly, reported on the technological and political intricacies that have made America a partner in the International Space Station. The station will be built in space in stages, and its first component was set for launch in November 1998. Learn what NASA expects to accomplish on page 42.


Francis Giacobetti

Stephen Hawking

In addition we bring you two stories that consider the fundamental relationship between cosmology and religion. A profile of the Vatican Observatory in Arizona begins on page 56, and an essay on the Conference on Science and the Spiritual Quest held at Berkeley this year appears on page 52.

But the most fascinating story in the issue must be a profile of cosmologist Stephen Hawking written by his biographer Kitty Ferguson. Because this profile (on page 64) and its subject so perfectly capture the rush of discovery that characterizes astronomy at the end of the 20th century, we are making a huge departure — putting Hawking's portrait on our cover.

As we worked on this issue, art director Carole Kramer and I considered several cover ideas, and actually produced four distinct efforts. In the final cover meeting, everyone agreed that the image needed to be Hawking. To ice the cake, look for Stephen Hawking's answer to one of our reader questions in Ask Astro this month (on page 112).

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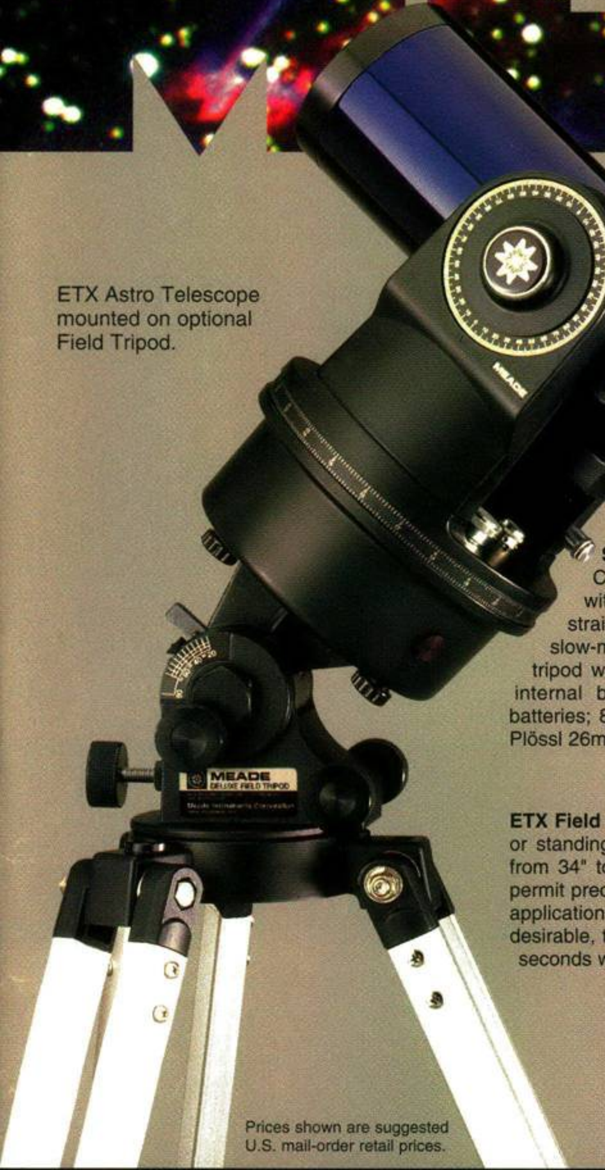
Diffraction-limited imaging and ultraportability ...at only $595, complete!



ETX Astro Telescope mounted on optional Field Tripod.

The revolutionary Meade ETX goes anywhere with you at a moment's notice and presents the finest optical images ever made available in an ultraportable telescope.

SPECIFICATIONS: ETX Astro Telescope — Includes Maksutov-Cassegrain optical tube assembly (D = 90mm, F = 1250mm, f/13.8) with EMC super multi-coatings; internal flip-mirror system for either straight-through or 90° observing position; equatorial fork mount with slow-motion controls, locks, and setting circles in R.A. and Dec; table tripod with elevation scale on center tripod leg; motor drive system with internal battery compartment accepting three (user-supplied) AA-size batteries; 8 x 21mm achromatic erect-image viewfinder; Series 4000 Super Plössl 26mm eyepiece (1.25"); operating instructions. Net weight 9 lbs.

$595 (+ $20 packing & shipping in the 48 states)

ETX Field Tripod — The rigid, full-length ETX Field Tripod allows for seated or standing observations through the telescope; tripod height is adjustable from 34" to 54". Micrometric controls in both azimuth and elevation-angle permit precise polar alignment of the telescope's fork mount for astronomical applications. For terrestrial observing, where altazimuth orientation is desirable, the tripod head tilts to 90°. The telescope attaches to the tripod in seconds with two thumbscrews. Net weight 11 lbs.

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Tilt and lock the ETX Field Tripod to 90° for terrestrial observing.

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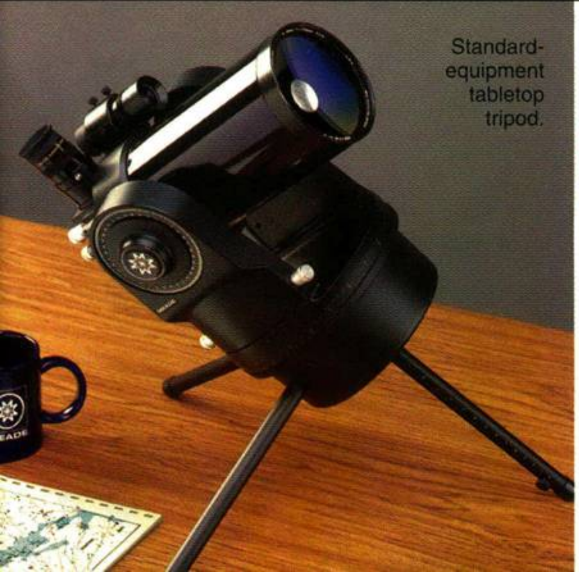
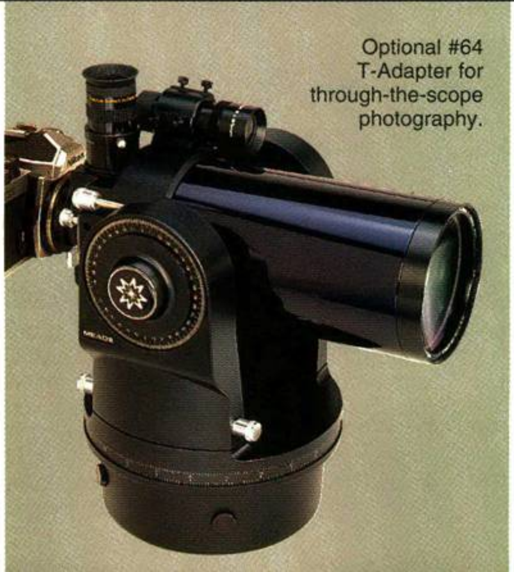


Standard-equipment tabletop tripod.



Optional #64 T-Adapter for through-the-scope photography.

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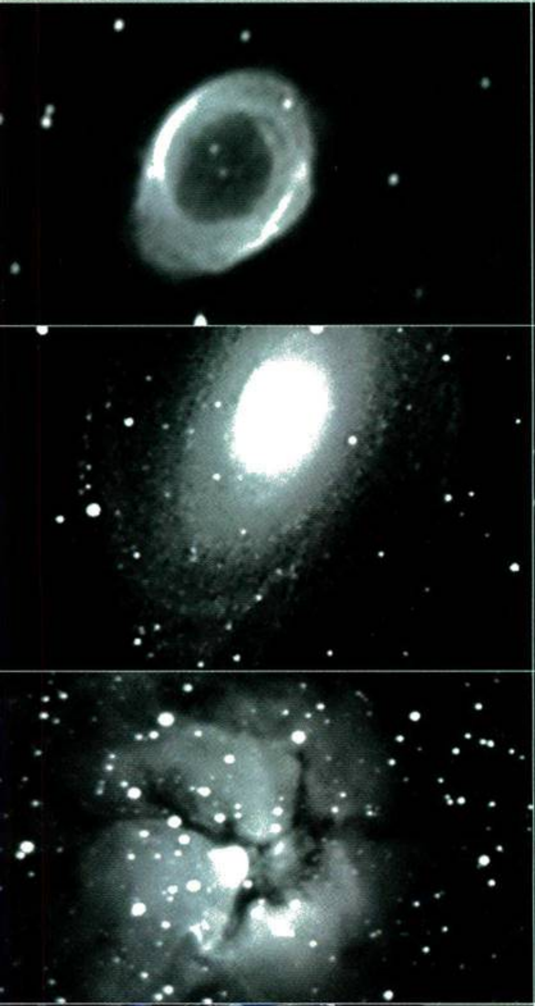
Pictor 208XT images *(top to bottom):* Ring Nebula (M57), 25" reflector, Jack Newton; Galaxy (M81) in Ursa Major, 12" LX200, Scott Roberts; Trifid Nebula (M20), 8" LX200, John Hoot.



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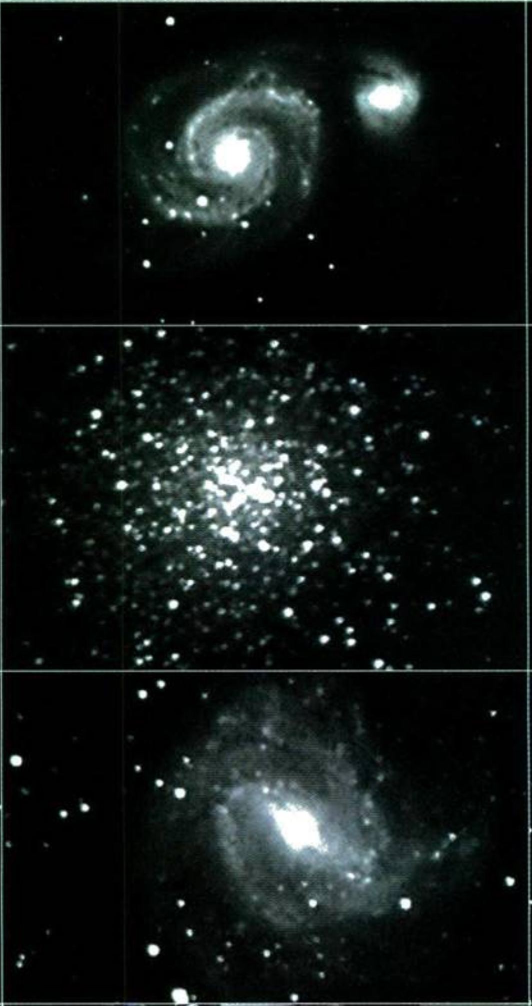
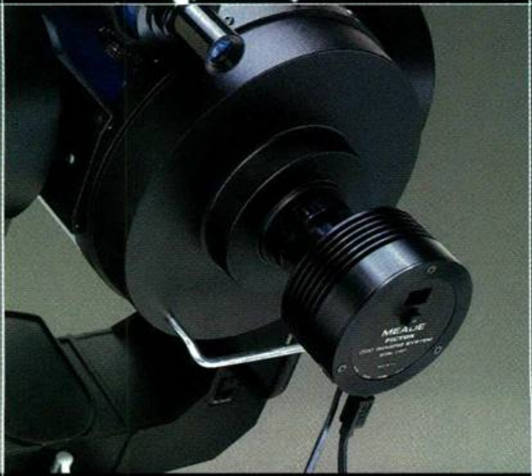
Pictor 216XT images: Whirlpool Galaxy (M51), 12" LX200, John Hoot; Globular Cluster (M13), 25" reflector, Jack Newton; Galaxy (M83) in Hydra, 12" LX200, Scott Roberts.





Pictor 216XT: $695 ***complete***

Pictor 416XT images: Saturn (in green light), 16" LX200, Dr. Donald Parker; Jupiter, 10" LX200 with Stellar Products AO-2 seeing adapter, Dr. Donald Bruns; Crab Nebula (M1), 25" reflector, Jack Newton.

Shipped **FREE** with Pictor 201XT Autoguider, CCD Off-Axis Guider, Image Orienter, and Epoch 2000ip Image Processing Software, as shown!

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includes $800 Meade CCD Equipment System

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Reflector — **$695.**

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Shown with optional #1702 Dual-Axis Drive System

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Experience all of the high-resolution optical performance and mechanical precision of a MEADE reflector, refractor, or Schmidt-Cassegrain, at a moderate pricing level. Each complete 500-Series model includes the all-new MEADE LXD 500 equatorial mount with dual-axis worm gears, engraved setting circles, micrometric slow-motion controls in RA and Dec, rigid aluminum tripod, and a full complement of accessories. Choose from among five models the one that's right for your budget and observing requirements. *For complete details send for your free copy of the Meade 100-page General Catalog.* Optional systems for Meade 500-Series telescopes include:

#1701 Single-Axis RA Drive System	**$145.**
#1702 Dual-Axis Drive System, with 4-speed hand controller	**195.**
#812 Polar Alignment Finder	**49.**

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Packing and shipping: 4" models—$55; 4.5" and 5"—$45; 8"—$65.

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MEADE STARFINDER DOBSONIANS

Now with Series 4000 Super Plössl 26mm eyepiece as *standard equipment!* Consider these features:

Series 4000 SP26mm Eyepiece (1.25"): The premium SP26mm ocular permits all Meade Starfinder Dobsonians to perform absolutely to their maximum capabilities. This $80 eyepiece is now **standard-equipment** on all Meade Dobsonians.

Primary and Secondary Mirrors of Low-Expansion Pyrex® Glass: Unlike the plate glass optics of other Dobsonians that can become thermally unstable, all Meade Dobsonian optics are made of Grade-A fine-annealed Pyrex glass — the exact same professional-quality optics used on Meade Starfinder Equatorials.

Rigid, Durable, Beautiful Dobsonian Mountings, manufactured of cabinet-quality materials, provide extremely smooth motions of the telescope in both altitude and azimuth. Both telescope axes ride on zero-backlash Teflon/Nylon bearings, facilitating the quick location and easy tracking of celestial objects.

Full-Size 1.25" Rack-and-Pinion Focuser: For smooth, precise focusing of the image without wobble or backlash. Focus travel is 2.6"; accepts 1.25" eyepieces.

4-Vane Steel Secondary Mirror System: Permits locked-in support and precise centration and alignment of the secondary mirror.

5 x 24mm Viewfinder: Included with all Starfinder Dobsonian models for quick object-location in the main telescope. With crosshair eyepiece and 2-ring bracket.

Optical Tubes: The same strong, spiral-wound Sonotubes™ used on Starfinder Equatorials *(right),* tubes with excellent insulating characteristics that reduce internal thermal currents to an absolute minimum.

Performance! *Meade Starfinder Dobsonians and Equatorials are the largest-selling Newtonian reflectors of their apertures in the world.* Every Starfinder model opens up the skies to an extremely wide range of serious visual observing; all 110 Messier objects, thousands of NGC objects — nebulae, galaxies, star clusters, in all their variations of form, color, and extent, as well as the Moon and planets in stunning high-resolution detail. Starfinder Dobsonians are telescopes for visual observing; motor-driven Starfinder Equatorials may be used, in addition, for lunar and planetary photography, and even for limited deep-space photography.

Packing & UPS Shipping Charges to any address in the 48 states: 6"—$39; 8"—$49; 10"—$69; 12.5"—$79; 16"—$45 packing, shipped truck freight collect.

$270 Dobsonian Deluxe Accessory Package...only $49.95!

Outfit your Meade Dobsonian with all of the most popular accessories for advanced observing. At the time you order any Dobsonian model, specify the following Deluxe Accessory Package for your telescope, in place of the standard-equipment focuser, viewfinder, and eyepiece, ***for a total of only $49.95 additional:***

- **1 - Meade #77 2" Giant Rack-and-Pinion Focuser,** with machined aluminum eyepiece-holders for both 2" and 1.25" eyepieces; includes drawtube lock and 2.6" focuser travel. *(reg. $59.95)*
- **1 - Meade #637 6 x 30mm Achromatic Viewfinder,** with wide 7° field; 2-ring metal bracket. *(reg. $49.95)*
- **2 - Meade Series 4000 Super Plössl 9.7mm and 26mm** multi-coated eyepieces — premium-grade eyepieces for high-resolution lunar, planetary, and deep-space observing. *(reg. $79.95 each)*

Purchased separately, the Deluxe Accessory Package sells for $269.80!

Meade Magellan I Telescope Computer System

Attach the optional Magellan I Telescope Computer System to your Starfinder Dobsonian and finding any of 12,218 celestial objects, or *any* object of known R.A. and Dec., is almost as easy as pointing the telescope! Magellan I's database includes the following objects:

7,840	NGC objects; the complete NGC catalog
4,093	IC objects from the Index Catalog
125	user-defined objects
110	Messier objects; the complete catalog
42	alignment stars for the Magellan system
8	major planets, from Mercury to Pluto
12,218	objects, total

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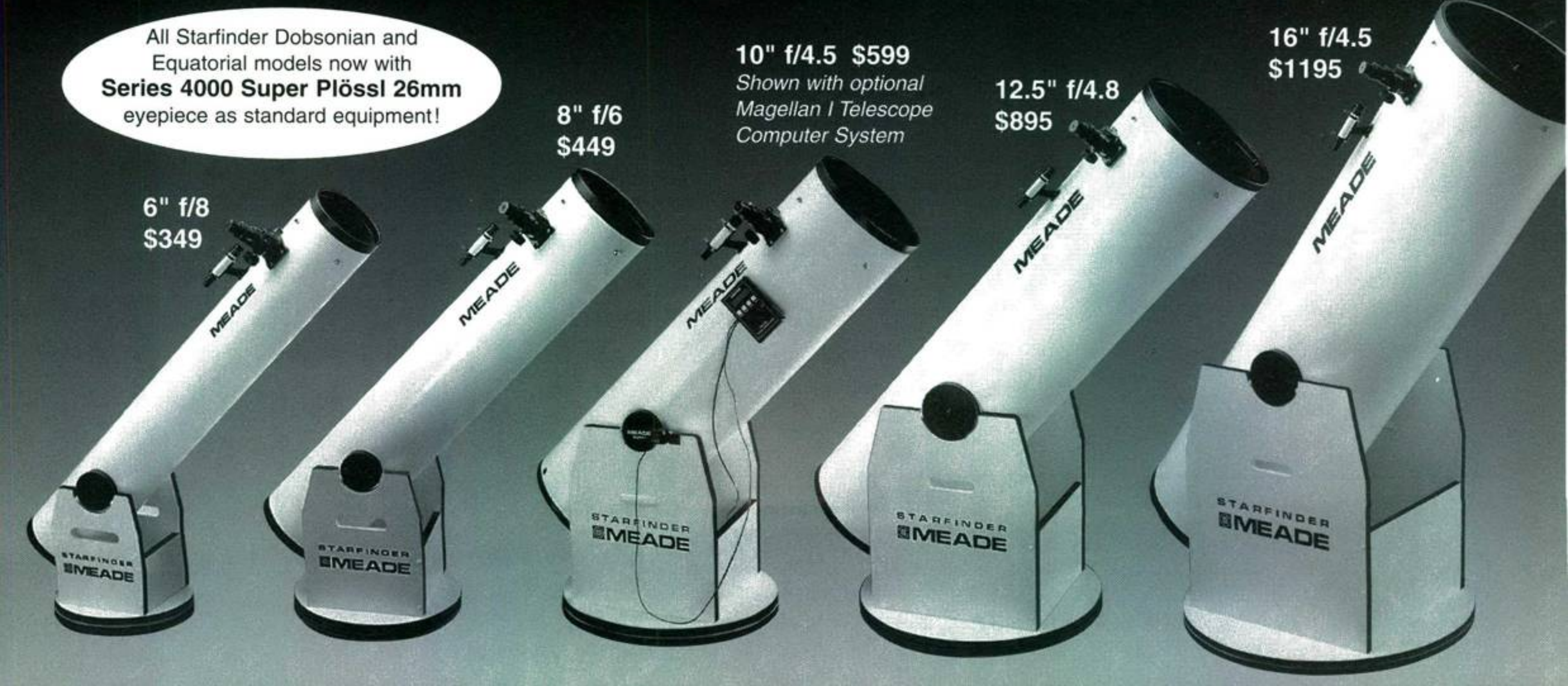
Magellan I is supplied *complete* with control/display unit (4" x 5" x 1.25"); premium-grade, high-resolution encoders for each telescope axis (encoder precision is 5.3 arc minutes); RS-232 serial interface; bracket for placement of the controller on the telescope tube; and attachment hardware. Just add the user-supplied 9v. transistor radio battery, and Magellan I is ready to use. First-time installation is quick and simple.

#2010: for Meade Starfinder Dobsonian
6", 8", 10", 12.5", or 16" . . . . $295.
Packing & shipping in the 48 states—$15.

STARFINDER DOBSONIAN TELESCOPES ***Shown with standard-equipment 5 x 24mm viewfinder and 1.25" rack-and-pinion focuser.***


All Starfinder Dobsonian and Equatorial models now with
Series 4000 Super Plössl 26mm
eyepiece as standard equipment!
6" f/8
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10" f/4.5 $599
Shown with optional Magellan I Telescope Computer System
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STARFINDER EQUATORIALS

With DC-powered drive systems for automatic tracking and Series 4000 Super Plössl 26mm eyepiece.

Professional-Grade Optical System: Hand-figured, parabolic primary mirror and elliptical flat secondary, both of Grade-A Pyrex glass. Optics are multi-coated and meet the theoretical limits of resolution.

Accessories and Components: Premium-grade multi-coated SP26mm eyepiece (1.25"); #637 6 x 30mm viewfinder with wide 7° field; strong, durable, spiral-wound optical tube with attractive white finish.

Precision Equatorial Mount: Manufactured of machined aluminum to tolerances of .001" or better, with 4"-dia. pier and die-cast tripod legs for rock-solid support of the optical tube. Moves effortlessly from object to object on precision bearing surfaces. Polar and Dec. shafts are 1" solid steel. Setting circles on both axes.

Battery-Powered Cordless Drive System! For fully automatic tracking of celestial objects. Operates over 50 hours from 6 (user-supplied) AA-batteries. Control panel also permits powering the telescope from 12v. auto cigarette lighter plug, using optional 25 ft. cord.

2" Giant Focuser: Meade #77 2" giant rack-and-pinion focuser is included as standard equipment, with eyepiece-holders for both 2" and 1.25" eyepieces.

Starfinder Equatorial 16: Includes equatorial mounting with 1.5" steel shafts, Sealmaster ball bearings, 6" dia. pier, and 6 x AA-size battery-powered worm gear drive; 8 x 50mm viewfinder; #77 2" giant focuser.

Packing & UPS Shipping Charges to any address in the 48 states: 6"—$65; 8"—$75; 10"—$90; 16"—$55 packing, shipped truck freight collect.

Meade Magellan Telescope Computer Systems

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TELESCOPE COMPUTER SYSTEM

Magellan I: Use the Magellan I computer to manually slew the telescope quickly to any of 12,218 database objects, or to any object of known R.A. and Dec. Specifications and object database are identical to Magellan I for Starfinder Dobsonians *(see facing page)*.

#2011: for Meade (DC-powered) Starfinder Equatorial 6", 8", or 10" . . . . $295.
#2012: for Meade (DC-powered) Starfinder Equatorial 16" . . . . 295.

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MAGELLAN II
COMPUTER-CORRECTOR
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Magellan II Computer-Corrector: Plug the Magellan II into the control panel of your Meade Starfinder Equatorial and you have all the capabilities of the Magellan I, above, including 12,218-object database, *plus* a 4-speed (2x, 8x, 16x, 32x), dual-axis, drive corrector/microslewing system.

#2018: for (DC-powered) Starfinder Equatorial 6", 8", 10" . . 495.
#2019: for (DC-powered) Starfinder Equatorial 16". . . . . 595.

Packing & shipping in the 48 states: Magellan I–$15, Magellan II–$20.

Special Eyepiece Offer! At the time you order any Meade Starfinder Equatorial telescope, you can buy a Meade Series 4000 Super Plössl 9.7mm eyepiece ***for only $29.95!*** *Purchased separately, the SP9.7mm eyepiece sells for $79.95.*

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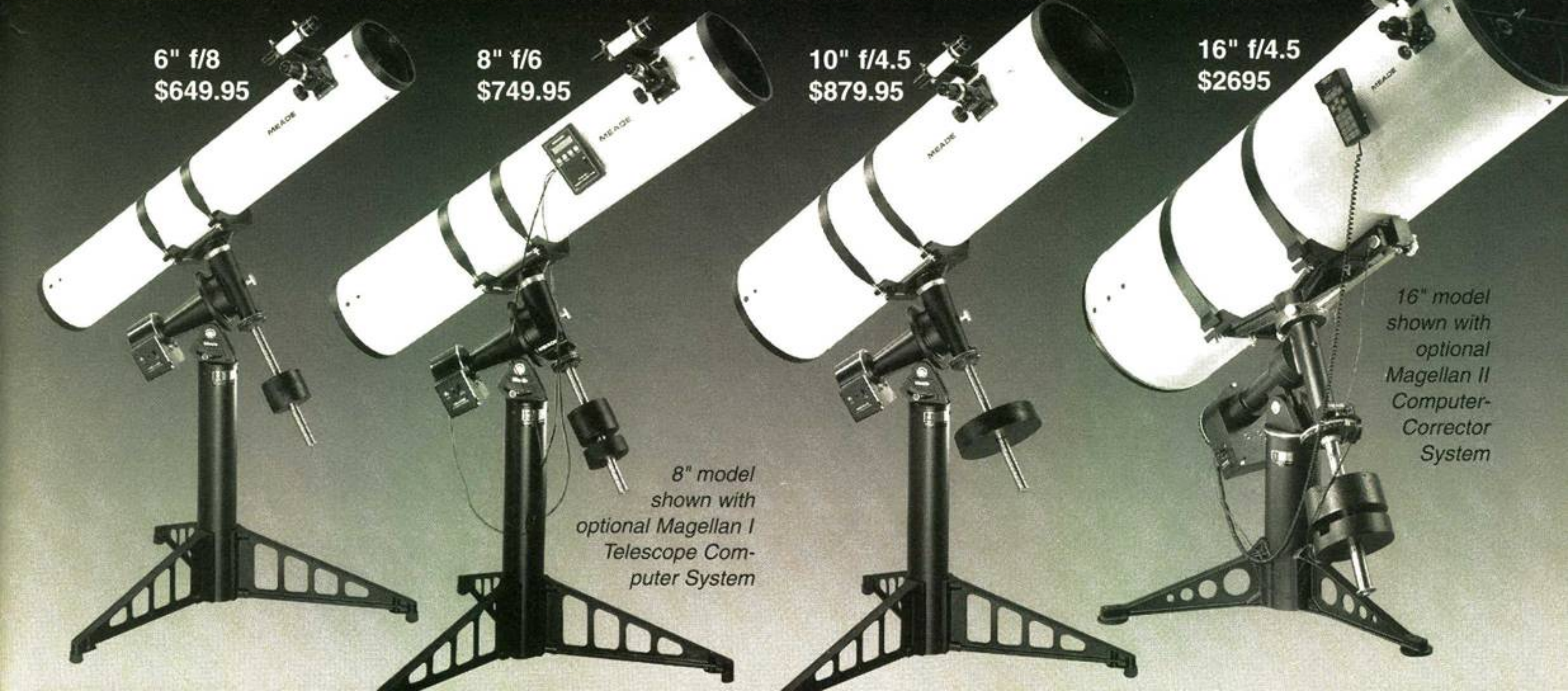
STARFINDER EQUATORIAL TELESCOPES ***Shown with standard-equipment 6 x 30mm or 8 x 50mm viewfinder and 2" giant focuser.***

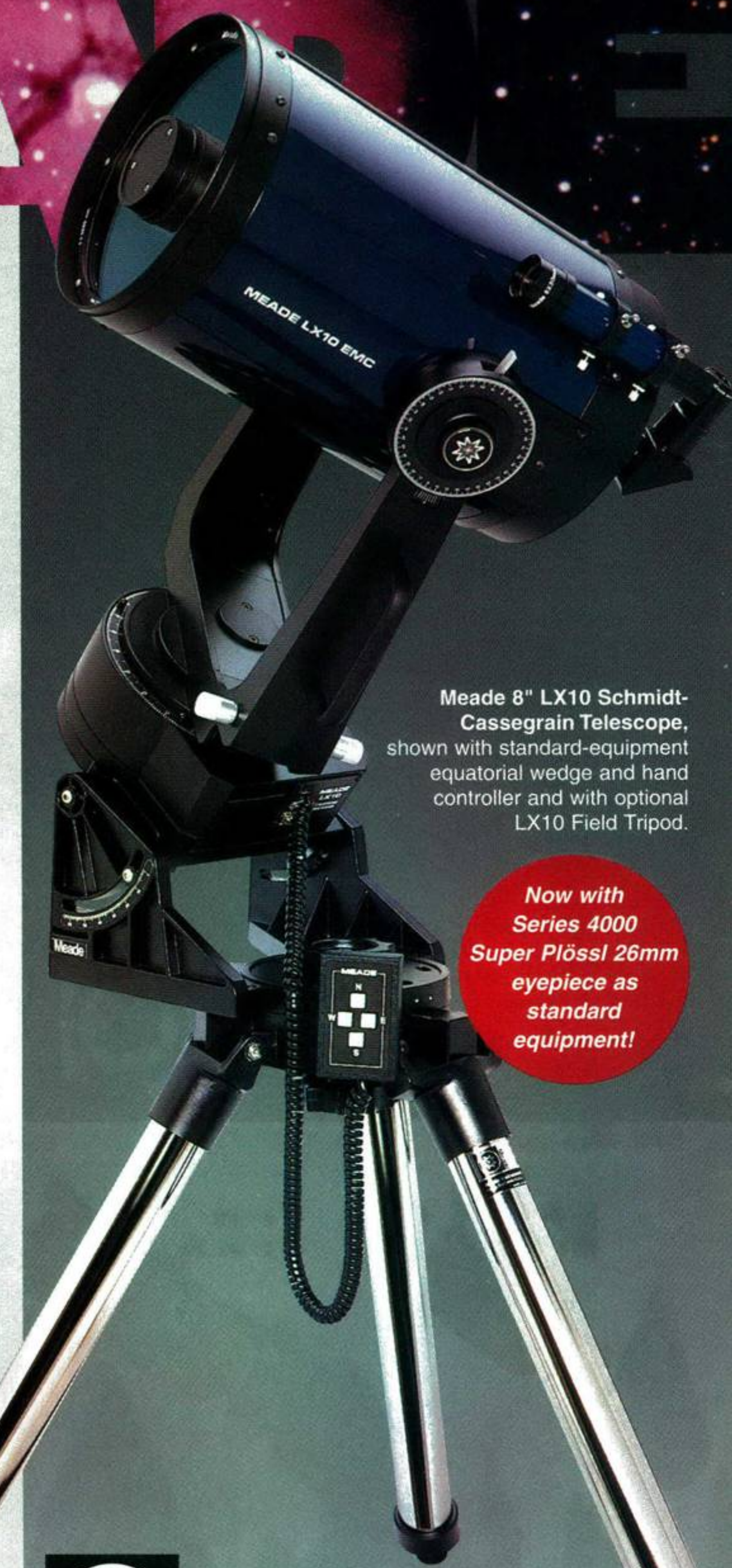


8" model shown with optional Magellan I Telescope Computer System

16" model shown with optional Magellan II Computer-Corrector System

8" LX10

8" LX10 DELUXE



Meade 8" LX10 Schmidt-Cassegrain Telescope, shown with standard-equipment equatorial wedge and hand controller and with optional LX10 Field Tripod.

Now with Series 4000 Super Plössl 26mm eyepiece as standard equipment!

The optical performance of a Meade 8" LX200 Schmidt-Cassegrain...for only *$995!*

8" LX10: For the serious amateur astronomer on a more limited budget, or for the more casual observer who nonetheless demands the very finest in optical performance, the Meade 8" LX10 satisfies every requirement. *Standard-equipment includes:*

Super-Multi-Coated Optical System: The *exact same* multi-coated 8" Schmidt-Cassegrain optical tube assembly as more expensive Meade 8" LX50 and LX200 models. **Series 4000 SP26mm eyepiece:** Complements the exquisite imaging of Meade 8" SC optics. **Equatorial Fork Mounting:** The relatively light weight, but very stable, LX10 fork mounting provides all of the rigidity required for sensitive high-power applications of the telescope, or for photographic or CCD imaging. **Cordless, DC-Powered Electronic Motor Drive:** With electronically-regulated DC servo motor for automatic *sidereal-rate* tracking; powered by four AA-size batteries that fit conveniently through the telescope's control panel; battery life is in excess of 50 hours. **Worm-Gear System:** The LX10's 5.75"-diameter worm gear produces extremely smooth, regular motion in R.A., with low periodic error — a periodic error that permits such advanced capabilities as long-exposure astrophotography or CCD imaging. **Hand Controller:** Essential for micro-guiding the telescope during long-exposure astrophotography, the LX10's pushbutton hand controller enables precise corrections in R.A. at 2x speed. With the optional electric Declination motor added to the telescope, the hand controller is functional at 2x speeds on both telescope axes.

SPECIFICATIONS: 8" Model LX10 — Includes 8" Schmidt-Cassegrain optical tube assembly with EMC super multi-coatings (D = 203mm; F = 2000mm, f/10); fork mount with setting circles, manual slow-motion controls, and locks on both axes; 5.75" LX worm gear reduction system; sidereal-rate electronically-regulated DC servo motor drive; 4-pushbutton hand controller for 2x speed corrections in R.A.; battery compartment accepting four (user-supplied) AA-size batteries (telescope may also be powered from an auto cigarette lighter plug, using optional 25 ft. cord); 6 x 30mm viewfinder; eyepiece-holder and diagonal prism (1.25"); SP26mm multi-coated eyepiece; standard equatorial wedge with elevation scale, fine elevation control, and 360° azimuth orientation capability; complete operating instructions. **$995.** (+ $65 packing & shipping in the 48 states)

8" LX10 Deluxe: At only $1149 the 8" LX10 Deluxe includes (a) the large-aperture Meade #544 8 x 50mm viewfinder (in place of the standard 6 x 30mm finder); (b) the LX10 Electric Declination Motor System, permitting dual-axis guiding corrections at 2x speed; and (c) Meade Epoch 2000 Jr. Sky Software with 10,000-object database — all at substantially lower cost than if the respective accessories were purchased separately.

SPECIFICATIONS: 8" Model LX10 Deluxe — Identical in all specifications to 8" Model LX10, above, but with Electric Declination Motor System provided as standard equipment, permitting dual-axis corrections at 2x speed; Meade #544 8 x 50mm achromatic viewfinder in place of 6 x 30mm viewfinder; and Meade Epoch 2000 Jr. Sky Software with 10,000-object database.

$1149. (+ $65 packing & shipping in the 48 states)

Field Tripod for LX10 or LX10 Deluxe	**195.**
Electric Declination Motor System for LX10	**95.**
#2014 Magellan I Telescope Computer System for LX10 or LX10 Deluxe, with 12,218-object database	**375.**

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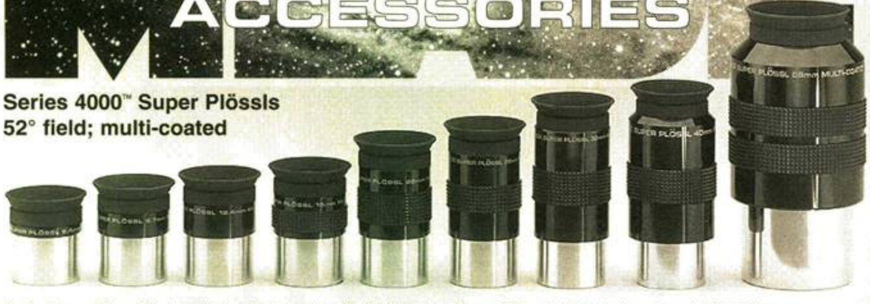
RESEARCH-GRADE ACCESSORIES

Series 4000™ Super Plössls
52° field; multi-coated



Meade 4-element Super Plössls, updated and redesigned to utilize the latest in optical glass-types, are the finest general-purpose eyepieces available. For observing hairline lunar and planetary detail, splitting close doubles, or for deep-space; guaranteed to deliver more contrast and image sharpness than any other brand. Rubber eyeguards fold down for eyeglass wearers–a feature not available on competing brands. Multi-coated. All focal lengths through 32mm are parfocal.

Super Plössls (SP; 4-elements; 1.25"; 52°):

6.4, 9.7, 12.4, 15, 20, 26mm	each:	**$79.95** (4.54)
32mm (52°); **40mm** (44°)	each:	**99.95** (5.26)
56mm (52°; 2")		**199.95** (7.02)

Series 4000™
2x Apochromatic Barlow Lens

#140: The most advanced Barlow lens available for commercial telescopes, the Meade #140 includes 3-element, multi-coated, air-spaced optics. Doubles the power of any eyepiece with which it is used and yields images absolutely unmatched in resolution, contrast and color correction. The #140 optically complements any telescope — refractor, reflector, or Schmidt-Cassegrain. Accepts 1.25" eyepieces. Mechanical components are of machined aluminum and brass. Lens diameter is 28mm; clear aperture 26mm.

$79.95 (5.26)

Series 4000™
Super Wide Angle
67° field; multi-coated

For exquisite wide-angle images at low-to-medium powers, with pinpoint edge-of-field resolution. Ideal for star fields, galaxies, and other deep-space phenomena. SWA 13.8mm, 18mm, and 24.5mm are superb complements to the #140 Barlow, above.

Super Wide Angle (SWA; 6-elements; 1.25"; 67°)–**13.8mm: $139.95** (4.54); **18mm: 149.95** (4.54); **24.5mm: 179.95** (5.26); **32mm** (2"): **239.95** (7.02); **40mm** (2"): **299.95** (7.02)

Series 4000™
Ultra Wide Angle
84° field;
multi-coated

The ultimate eyepieces; extreme image sharpness over an amazing 84° field. A perfect optical match with Schmidt-Cassegrains and fast Newtonians.

Ultra Wide Angle (UWA; 8-elements; 1.25"; 84°)– **4.7mm: $169.95** (5.26); **6.7mm: 199.95** (5.26); **8.8mm** (1.25"/2"): **239.95** (7.02); **14mm** (1.25"/2"): **299.95** (7.02)

World's Most Advanced Illuminated Reticle Eyepiece

Series 4000 Plössl 9mm, with rubber eyecup and micrometric X-Y positioning of the reticle within the field. Greatly facilitates locking on the guide star. Sharp high-power imaging, excellent eye relief. Wireless red LED illuminator with adjustable brightness control. Multi-coated optics. **Internal batteries included.** Bullseye reticle. 1.25".

$149.95 (6.14)

Series 4000 Plössl 9mm—Same as above but with 6 ft. cord and plug for Meade LX3, LX5, LX6, LX100, LX200, and APO power panels, in place of wireless illuminator.

$129.95 (5.26)

Series 3000™ Plössls
50° field; multi-coated

Meade Series 3000 Plössls yield the finest image corrections obtainable from the classical 4-element Plössl design. Focal lengths from 5mm through 25mm are parfocal, so that, at most, only slight refocusing of the image is necessary from eyepiece to eyepiece. Unlike competing moderately-priced Plössls, Meade Series 3000's are **multi-coated** for maximum light transmission and image contrast. Chrome-plated brass barrels are threaded for standard filters. All eyepieces are fitted with fold-down rubber eyecups for comfortable observing. The PL40mm *(far right in photo)*, an excellent complement to any ocular set, produces spectacular low-power, wide fields, ideal for scanning the Milky Way. Manufactured exclusively to Meade optical designs, Series 3000 Plössls yield fine, high-resolution results on reflectors, refractors, and Schmidt-Cassegrains of any focal ratio.

Series 3000 Plössls (4-elements; 1.25"; 50°)
5, 6.7, 9.5, 16, 25mm each: **$49.95** (3.86); **40mm** (44° field): **$79.95** (3.86)

Series 4000 Photo-Visual Color Filters (1.25")–Premium filters, made of purest crown optical glass, dyed in the mass. For increased contrast and resolution on the Moon and planets. Thread into the barrels of virtually all 1.25" eyepieces sold today. Fully coated.

#8 Lt. Yellow; #11 Yellow Green; #12 Yellow; #21 Orange; #23A Lt. Red; #25A Red; #38A Dark Blue; #47 Violet; #56 Lt. Green; #58 Green; #80A Blue; #82A Lt. Blue each **$14.95** (2.73)

Set #1–4 filters: #12, #23A, #58, #80A	**49.95** (4.54)
Set #2–4 filters: #11, #25A, #47, #82A	**49.95** (4.54)
Set #3–4 filters: #8, #21, #38A, #56	**49.95** (4.54)

Series 4000 Moon Filter (#ND96): Reduces glare and irradiation during lunar observing. 13% uniform light transmission across the visual spectrum. Threads into 1.25" barrels. **$16.95** (2.73)

Series 4000™
f/6.3 Focal Reducer/ Field Flattener

Manufactured to exclusive Meade optical designs; threads on to any Meade or Celestron Schmidt-Cassegrain rear cell and converts f/10 scopes to f/6.3 (or f/6.3 SCT's to f/4), while significantly flattening the field. Use with SCT visual or photo accessories. Actual visual field is increased by 56%, for fine wide-field views of star fields and nebulae. In astrophotography, reduces exposure times by about 50%, while producing an actual field diameter of 1.5" at the film plane. A tremendous aid with CCD imagers in reducing image size for locating and centering images on CCD chips. 4-element optics; multi-coated; 41mm clear aperture. **$129.95** (5.26)

#911B
#910B
#908B
#911N
#910N
#908N

Series 4000 Nebular Filters—Premium multi-layer interference filters, the finest obtainable. Use broadband ("B") filters to block most forms of light pollution; use narrowband ("N") filters in heavily light-polluted areas or for extremely high-contrast observing of faint nebulae.

#908B–Threads into 1.25" eyepieces, 26mm dia.	**79.95** (4.54)
#910B–Threads into 2" eyepieces, 44mm dia.	**119.95** (5.26)
#911B–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia.	**99.95** (5.26)
#908N–Threads into 1.25" eyepieces, 26mm dia.	**89.95** (4.54)
#910N–Threads into 2" eyepieces, 44mm dia.	**129.95** (5.26)
#911N–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia.	**119.95** (5.26)

New!

#911X
#910X
#908X

Series 4000 Oxygen-III Filters Observe diffuse emission and planetary nebulae as you never thought possible! Exclusive Meade *60-layer* interference coating technology isolates the 496nm and 501nm O-III lines to tremendously enhance observable nebular structural detail in all telescopes.

#908X–Threads into 1.25" eyepieces, 26mm dia.	**99.95** (4.54)
#910X–Threads into 2" eyepieces, 44mm dia.	**159.95** (5.26)
#911X–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia.	**149.95** (5.26)

Series 4000 Zoom Eyepiece

New!

The first zoom eyepiece—ever—to yield absolutely uncompromised resolution, color correction, and image brightness. Includes 8 elements, zooms from 7.7mm to 23.1mm with pinpoint imaging from edge to edge. Fully multicoated optics permit 99.8% light transmission at each air-to-glass surface. Apparent field 62° at 7.7mm; fold-down rubber eyecup; threaded for filters; 1.25".

$295. (7.02)

#905 Variable Polarizer (1.25")

For glare reduction in observing the Moon. Includes two Polarizer filters mounted in a machined cell and permits continuously variable light transmission from 5% to 25%, to compensate for varying lunar surface brightness according to the Moon's phase and the aperture of the telescope. Accepts 1.25" eyepieces. **$49.95** (5.26)

2x Telenegative Barlow (1.25")

#122: Doubles eyepiece power with sharp, high-resolution, high-contrast imaging on telescopes of all types. 27mm dia. (26mm clear aperture). Excellent corrections for chromatic and spherical aberrations at all photo-visual wavelengths. Multi-coated. 1.25"

$47.95 (4.54)

2x Short-Focus Barlow (1.25")

#126: Only 2.5" long, the #126 works well with any telescope accepting 1.25" eyepieces, even those with limited focus range. Maintains the high image quality of the #122, above. Insert the #126 into star diagonal for 2x or insert star diagonal into #126 for 3x. 26mm clear aperture. Multi-coated. **$47.95** (4.54)

2x-3x Variable Barlow (1.25")

#127: Precision internal sliding lens assembly permits continuously variable power settings between 2x and 3x. Engraved scale indicates power in use. Yields bright, sharp, high-contrast images on telescopes of all types. Multi-coated; 1.25".

$59.95 (4.54)

45° Erecting Prisms

Fully coated roof prisms to invert the astronomical image in Schmidt-Cassegrains or refractors during terrestrial observations, while presenting a convenient 45° observing angle. Specify **#927** (.965"), **#928** (1.25"), or **#931** (fits .965" focuser, accepts 1.25" eyepieces).

$42.95 (3.86)

Modified Achromatic Eyepieces

Meade 3-element MA eyepieces yield sharp, well-corrected images on the Moon, planets, and deep-space at a reasonable price. Multi-coated; threaded for filters; 1.25" barrel diameter. Apparent field: 40°. **MA 9, 12, 25, 40mm.**

each: **$37.95** (4.54)

MA12mm Illuminated Reticle Eyepiece

Excellent 3-element optical system, long eye relief, fully coated, with double crossline reticle. Wireless red LED illuminator and variable brightness control. 1.25" **Batteries included.** **$99.95** (3.45)

As above but with 6 ft. cord and plug for Meade telescopes with power panels, in place of wireless illuminator. **$79.95** (5.26)

Camera Adapters

Professional-quality adapters for rigid coupling of telescope-to-camera. Use for either Eyepiece-Projection or Prime Focus. Precision-machined of aluminum and brass, threaded for filters. Use with T-mount, available separately.

.965": $27.95; **1.25": $29.95** (3.86)

Variable Tele-Extender

For eyepiece-projection photography with any Meade or Celestron SCT. Threads on to eyepiece-holder. Sliding cell with lock permits wide range of projection magnifications with the same eyepiece. Use with T-mount for your camera.

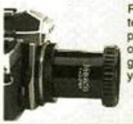
$39.95 (3.86)

Variable-Projection Camera Adapter (1.25")

Machined sliding cell allows variable projection power in eyepiece-projection photography; permits precise selection of correct photo power in lunar and planetary photography; threaded for filters. Use with T-mount for your camera.

$39.95 (3.86)

T-Adapters for SCT's



Rigidly couples camera to telescope for prime focus photography with any Meade or Celestron Schmidt-Cassegrain. Use with T-Mount for your 35mm camera.

$26.95 (3.86)

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TALKING BACK
FROM OUR READERS

Small-Comet Fallout

I was impressed with "Seeing Spots" (October 1998). Although it was not mentioned in the article about the controversial mini comets discovered by University of Iowa physicist Louis Frank, I wondered about the possible connection between these mini comets and nacreous clouds that occur at polar latitudes.

(Nacreous, or mother-of-pearl, clouds are beautifully colored clouds that form from tiny ice crystals up to about 18 miles (30 kilometers) in the stratosphere when the air temperature is below –80° C. Their great height allows them to be illuminated by the sun long after sunset and seen from the ground.)

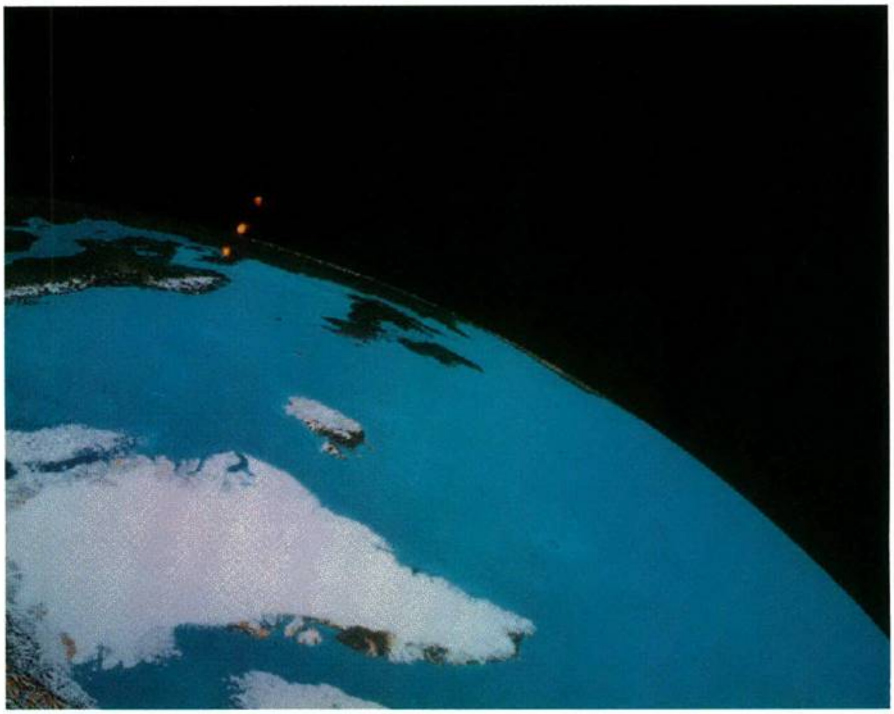
Could the comets that Frank discovered be the source of these clouds? — *Joseph Dobos, Black Hawk, South Dakota*

Mr. Dobos is probably correct in suggesting that the small comets may be the source of these dim clouds in the middle and upper stratosphere.

In order to understand the plausibility of his suggestion it is necessary to estimate the course of a small-comet water cloud as it forms and penetrates the atmosphere.

The speed of that cloud slows from the comet's initial-impact speed of 43,200 miles per hour (20 kilometers per second) at an altitude of about 155 miles (250 kilometers) to only 100 to 200 mph (0.045 to 0.09 kilometer per second) at the stratopause at an altitude of 31 miles (50 kilometers). The mass of cometary water and accumulated atmospheric gases will be carried from the stratopause at least to the middle of the stratosphere before they disperse.

Under the proper atmospheric conditions, it is quite possible that this diluted cometary water can produce a nacreous cloud and be seen in the proper lighting conditions. — Physicist Lou Frank, University of Iowa, Iowa City


Arc Science Simulations/University of Iowa/NASA

These intense "glows" taken by the Polar spacecraft about six seconds apart on December 31, 1996, are about 2,000 miles above Earth, which is artificially superimposed in this picture.

Offended by Letter

One would not expect a publication on astronomy to become a forum for Catholic-bashing, but that's what we found in the "Talking Back" section of your October issue. Letter-writer Paul Roland's attempt to suggest Catholic Church culpability in the Holocaust is easily refuted.

Mr. Roland needs to research these historical matters in far greater detail before he unfairly implicates the Catholic Church. — *Rick Hinshaw, Catholic League for Religious and Civil Rights, New York, New York*

For 25 years *Astronomy* magazine has been a valuable source of information about our hobby. It has always done a pretty good job of presenting us with the latest technologies and news. Despite that, I am angered that *Astronomy* allowed itself to be used as an avenue of hate and bigotry in a letter published in the October issue by Paul Roland.

While I categorically disagree with Mr. Roland's assertions and assumptions about the Catholic Church and any roles it may or may not have played in history, he has a right to his opinion. I think his logic and arguments are flawed because he simply hasn't done his homework. His letter is filled with misleading half-truths and, in some cases, false statements. — *Bill O'Donnell, Omaha, Nebraska*

I am sorry to those who were offended by the letter in our October issue. I was raised in the Catholic Church and feel close to it still, but I didn't recognize Mr. Roland's ideas as hateful as much as controversial. I disagree with the intent of his letter throughout and therefore probably went overboard to let him express his thoughts. We often run letters in

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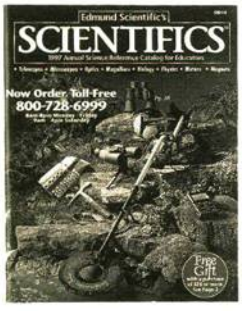
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Astronomy *with which we disagree. If I had thought I was offending our readership I certainly would not have printed this letter. I apologize.* — Bonnie Bilyeu Gordon, Editor

Teenager Promotes Astronomy

I am only 15 years old, but I have been fascinated by astronomy for more than five years. However, it is very hard for me to participate in astronomical events. Small towns do not have observatories or science centers. I am the only one of my peers, most of whom can't distinguish Saturn from Jupiter, who likes astronomy.

Who is responsible for astronomy illiteracy? I think schools are partly to blame. None of the six schools in my hometown has an astronomy course. I think this is unwise because some future jobs most likely will depend on people who understand the universe.

Astronomy keeps me up to date. I also like books by the late Carl Sagan and I enjoyed his television series *Cosmos*. I recommend them to my friends, but they say they probably wouldn't understand.

From this teenager's point of view, ignorance is a curse. Astronomers should do everything in their power to educate the public because, if they don't, who will? — *Candace Coonan, Alberta, Canada*

Astronomers Plead for SETI Funding

The following petition supporting renewal of SETI funding will be delivered to President Clinton:

The discovery of what may be fossils of microbiological life on Mars, which you announced to the public on August 7, 1996, has rekindled popular interest in the momentous question of whether humankind is alone in the universe. We are writing to urge that the federal government restore its support of a program that — though modest in scale and inexpensive to operate — could answer that question.

The project is SETI, the Search for Extraterrestrial Intelligence. Inaugurated October 12, 1992, NASA's SETI program ranked as the most thorough effort ever made to search the skies for radio signals from nonhuman civilizations. Because there are so many stars — several hundred billion stars in our galaxy alone — astronomers calculated that years of searching would be required before a signal was acquired, even if hundreds of worlds are emitting radio beacons that our equipment can detect. For that reason, NASA had planned to fund the SETI program through at least the year 2002. At a cost of only $12 million per year, SETI was a scientific bargain. But, sadly, funding was cut to zero in September 1993, when the SETI radiotelescopes had been listening for less than one year. Since then it has run as Project Phoenix with private funds at a reduced level.

Mr. President, a NASA SETI project can capture the public imagination, reaping educational benefits to our young people far out of proportion to its bargain-basement cost. It can help draw imaginative, visionary individuals into the space agency, building on the estimable efforts in that direction already undertaken by you and NASA Administrator Daniel Goldin. And of course, should it succeed, contact with an extraterrestrial civilization would constitute the most spectacular discovery in the history of humankind.

Therefore, we the undersigned urge that you restore government SETI funding in your next budget. — *Steven Jay Gould, Philip Morrison, Paul Horowitz, George Greenstein, Dennis Overbye, James Gleick, Jack McDevitt, Allen Tough, Jerry Ehman, Bob Dixon, Geoffrey Marcy, Paul Butler, Dan Werthimer, Gero von Randow, Kunitomo Sakurai, Greg Bear, Brian W. Aldiss, Timothy Ferris, Claudio Maccone, Arthur C. Clarke, Stelio Montebugnoli, Andrea Maccaferri, Alessandro Cattani, Ann Druyan, and Bonnie Bilyeu Gordon*

Telescope Tinkering

I recently built my own 10-inch, f/5.6 PortaScope that is similar to one featured in *Astronomy*'s February 1995 issue. It is my first telescope and on the advice of several suppliers I made a few minor changes that seemed to improve its performance.

I used a 1.83-inch mirror because it gave a fully illuminated field of view. I used it instead of the recommended 2.6-inch mirror. I simplified the mirror cell by using a standard RTV adhesive to glue the mirror to a plywood disk. I also used a laser to initially collimate,

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or precisely align, the mirrors. I used Teflon and textured Formica as bearings instead of the recommended nylon. And I glued a strip of Velcro to the tube as a mate to a moveable wrist weight, which worked as a device to balance the telescope.

For its size, the scope is inexpensive and easy to use. — *Walt Conrad, Henderson, Nevada*

Memory Lane

I enjoyed all the articles in the August issue, especially "Telescope-Making Revolution," by Richard Berry. A reference to the Criterion Dynascope RV-6 took me back to 1969, when I was a 14-year-old boy reading every astronomy book in my public library. After reading the telescope advertisements in *Sky & Telescope* (you weren't around then), I longed for a six-inch reflector pictured in an ad: the RV-6. It was $200.

For months I saved every penny I earned and eventually accumulated $100. My mother gave me the remaining $100, and in October 1969 we placed our order for the telescope. The two-month wait was agonizing. I thought it would never end. But when the telescope arrived I was thrilled.

From my backyard I viewed the moon, planets, and the Orion nebula. I especially enjoyed spending summer nights scanning the Milky Way.

I now have a Dobsonian telescope, but I will never forget my first scope. Thanks for reminding me. — *Steven DePalma, Holbrook, New York*

Correction

On page 104 of the October issue, a typographical error in a story about the Paramount GT-1100 Robotic Telescope Mount understated the size of one of its key features. The mount has Byers 11-inch research-grade right ascension gears that ensure pinpoint stars. Our apologies. A

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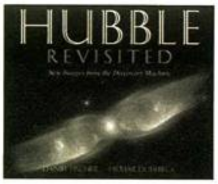

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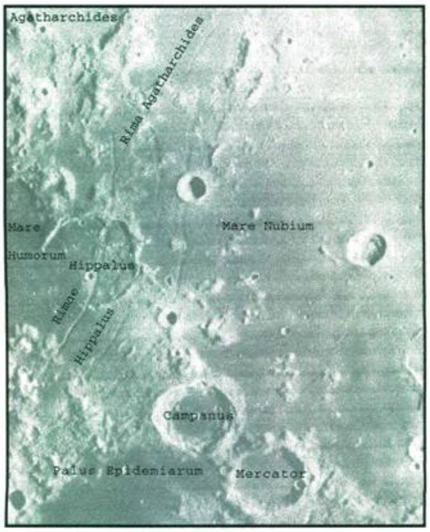

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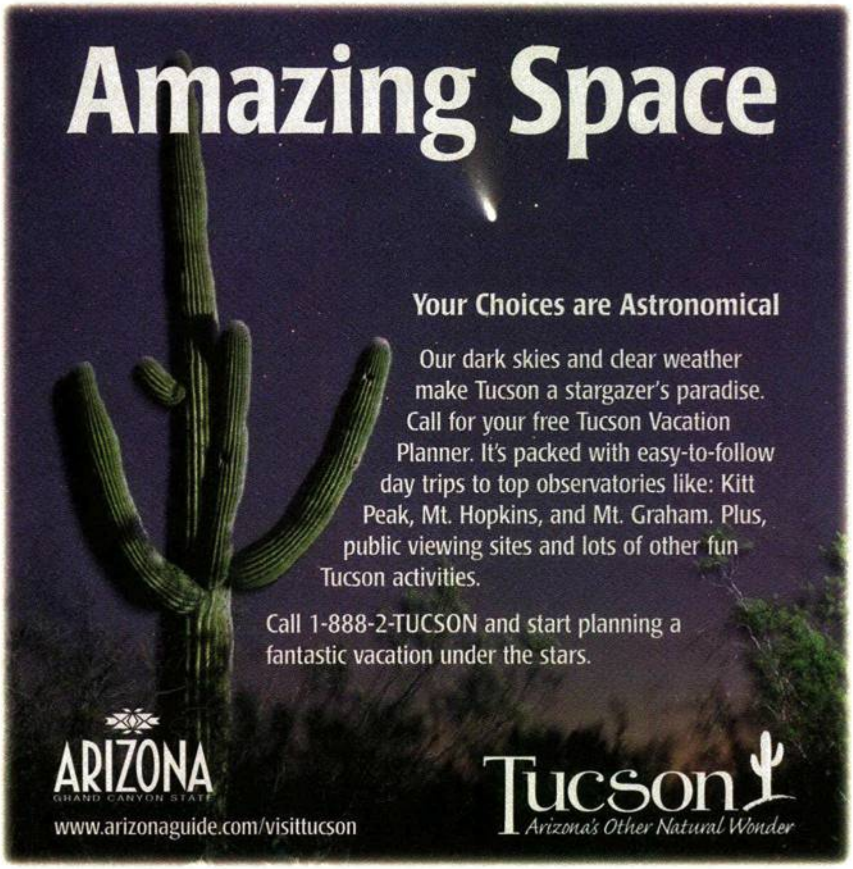

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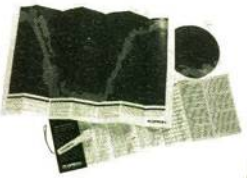

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MARS GLOBAL SURVEYOR

Martian Moon Covered by Dust

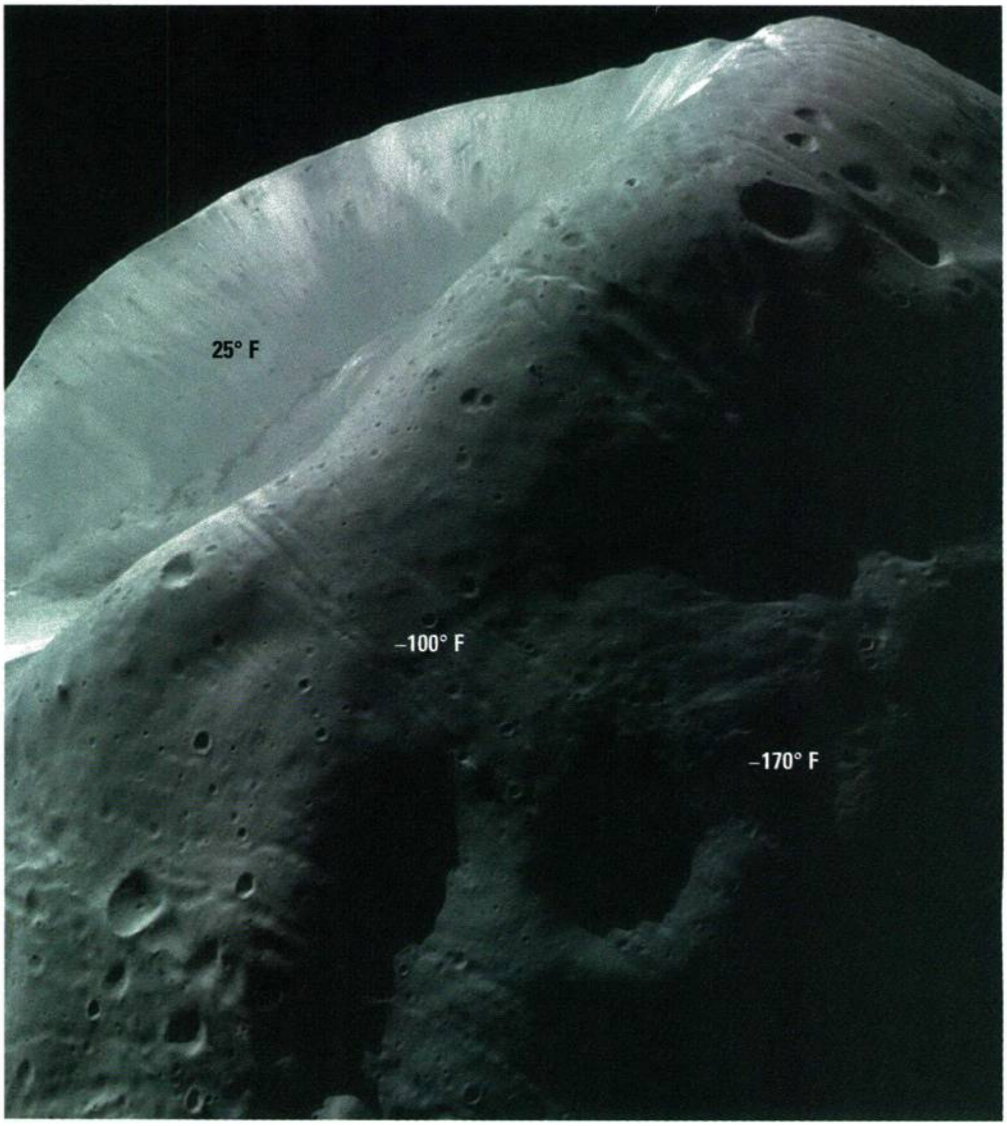
▶ On August 19, Mars Global Surveyor obtained striking new images and temperature data of Phobos, the larger of Mars's two moons. The images show part of the rim of the giant crater Stickney and the surrounding cratered terrain. The 6-mile-wide (10 km) Stickney is so large relative to Phobos (which is 17 miles across at its widest) that the impact almost blew the satellite apart. Swarms of fracture-like grooves radiate from the crater.

Temperatures measured by the Mars Global Surveyor's Thermal Emission Spectrometer tell us about the surface material. The daytime surface temperature reaches about 25° F (–4° C), but it plummets to –170° F (–112° C) less than an hour after sunset. This 195° F temperature swing reveals that the surface is covered by fine dust that is probably at least three feet (one meter) deep. Bare rock would heat up in the daytime, conduct heat into the moon's interior, and take a long time to cool off at night. Dust, however, insulates the subsurface layers so that they remain cold. Only the surface heats up in the daytime, and it cools off immediately at night.

In 1971, Steven Soter of Cornell University pointed out that meteorite impacts dislodge debris from Phobos. The debris goes into orbit around Mars and ends up hitting Phobos again. In other words, Phobos is sandblasted by its own debris. This process may have built up the dust layer, blanketing many of the surface features and creating the rather smooth surface seen in the new pictures.

The images, which reveal details the size of a small office building, shed light on small bodies in general. Spacecraft photos of asteroids Gaspra, Ida, and Mathilde do not show such small details. The closest Viking views of Phobos have comparable resolution, but were blurred by the spacecraft's motion. Phobos itself might be an asteroid captured into orbit around Mars, but questions remain as to how similar surface processes shaping Phobos, in Mars orbit, are to those that shaped asteroids.

— William K. Hartmann,
Planetary Science Institute



Malin Space Science Systems/NASA

Phobos, the larger of Mars's two moons, is darker than an asphalt parking lot. This new Mars Global Surveyor image shows boulders and small craters only 40 feet (12 meters) across. Measurements from the spacecraft's Thermal Emission Spectrometer show that Phobos's surface temperature plunges rapidly from day *to night, indicating* that the moon is covered by a layer of dust about 3 feet (1 meter) deep.

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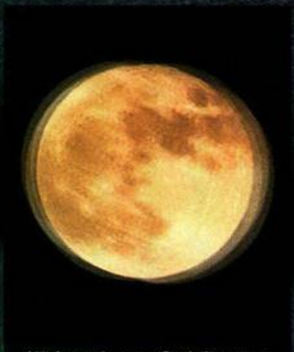

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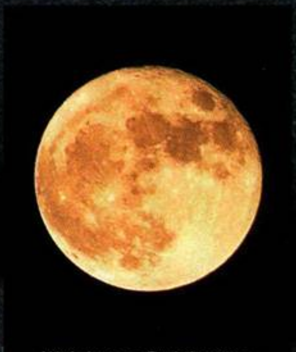

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EARLY UNIVERSE

Young Galaxies Ignite

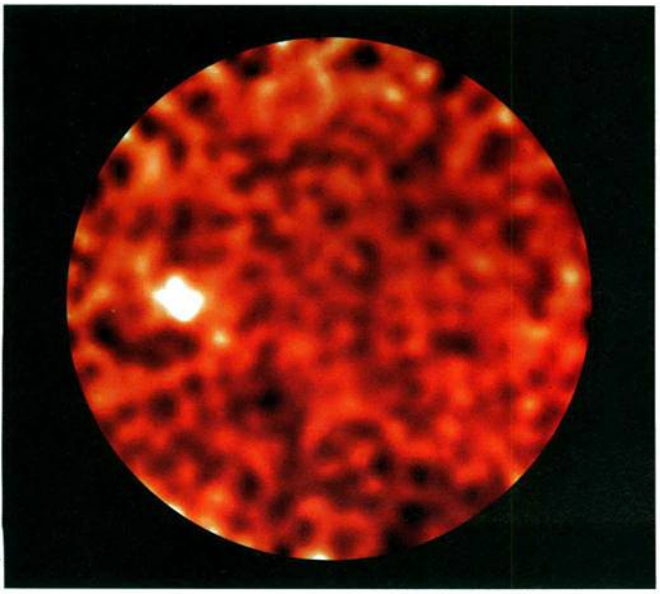
▶ Two teams of astronomers using a revolutionary new detector have discovered a population of previously unseen galaxies in the early universe. The galaxies appear to be forming stars at prodigious rates, suggesting that galaxies were forming the majority of their stars much earlier than had been thought. The teams, one led by Amy Barger of the University of Hawaii and the other by David Hughes of the University of Edinburgh in Scotland, reported their results in the July 16 *Nature*.

The discoveries indicate that massive star formation was occurring in galaxies when the universe was only one-eighth of its present age, roughly 11 billion years ago. "These observations are an important piece of the puzzle," says Barger. "They will contribute significantly to our understanding of how objects in the universe formed and evolved."

Both groups used a detector known as SCUBA (Submillimetre Common-User Bolometer Array), recently installed on the James Clerk Maxwell Telescope in Hawaii. SCUBA detected the galaxies behind a vast curtain of dust that blocks other telescopes' views of the

(see "Young Galaxies," p. 28)

This image, taken by the SCUBA submillimeter wave detector, records the glow of dust in distant, star-forming galaxies.



Amy Barger, Lennox Cowie (University of Hawaii), et al.

DARK MATTER

WIMPs and MACHOs Duke It Out

▶ Dark matter — the mysterious stuff that comprises most of the universe's mass but remains invisible to telescopes — refuses to yield its secrets. New results from an international team of scientists have raised more questions than they have answered, meaning astronomers still can't tell us what the universe is made of.

The team is looking for hypothetical objects in the Milky Way's halo called MACHOs (short for MAssive Compact Halo Objects). To find MACHOs, the scientists are on the lookout for gravitational microlensing, a prediction of Albert Einstein's general theory of relativity. The team uses a 50-inch telescope at the Mount Stromlo Observatory in Australia to monitor tens of millions of stars every night in the Large and Small Magellanic Clouds, the Milky Way's two largest satellite galaxies. If a MACHO passes between Earth and a star in either one of the Magellanic Clouds, it will act as a lens, amplifying the light of the background star.

At an August conference in Canberra, Australia, team leader Charles Alcock of the Lawrence Livermore National Laboratory in California reported a total of 15 microlensing events, up from the 7 events reported in 1996. Based on these numbers, says Alcock, MACHOs with typical masses of about half a sun could account for about half of the Milky Way Galaxy's dark matter.

But other scientists are raising the caution flag. A reliable distance has been determined for only one of the 15 lenses, and that lens was an ordinary star in the Small Magellanic Cloud, not in the Milky Way's halo. "We'd like to establish that this stuff is in the halo, but at this point we really can't do that," concedes team member David Bennett of the University of Notre Dame. Some astronomers think that all the lenses are in the Magellanic Clouds, although Bennett responds, "There isn't a model of the Magellanic Clouds that can explain all these events as self-lensing."

"Nobody wants half-solar-mass lenses, it just doesn't make sense," says Fermilab cosmologist Rocky Kolb. Ordinary stars in the halo with half the sun's mass would have been seen long ago. The MACHOs could be burned out stars known as white dwarfs, but the formation of white dwarfs should have polluted the surrounding gas with detectable amounts of heavy elements. The MACHOs could be small black holes that formed moments after the Big Bang, but this idea borders on pure speculation. "There isn't any model that doesn't have at least one strike against it," says Bennett.

If the dark matter isn't MACHOs, it could be WIMPs (Weakly Interacting Massive Particles) — ghostly particles that barely interact with normal matter. "That's my interpretation," says Kolb, "but that's what I want it to be."

— ROBERT NAEYE

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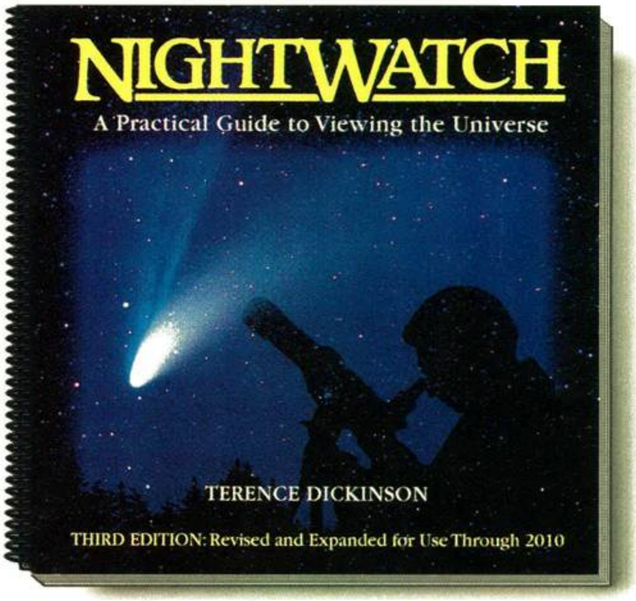

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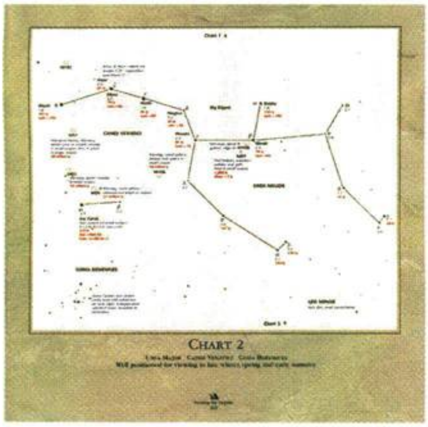

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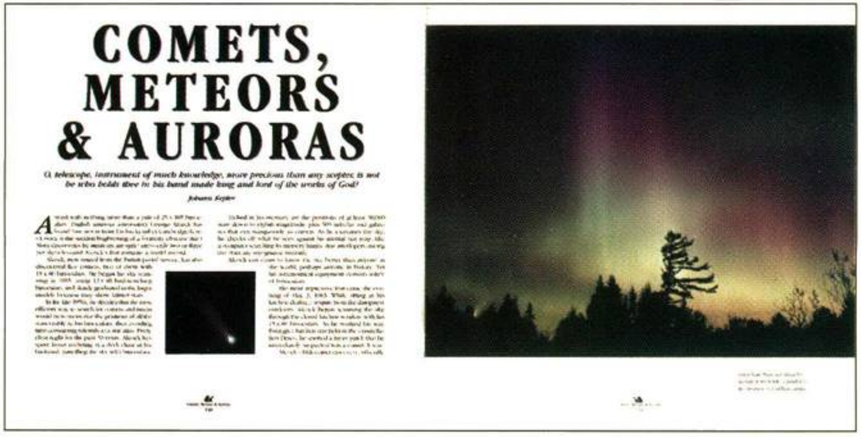

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(Young Galaxies)

early universe. It finds hot young stars in the early universe indirectly: The stars' visible and ultraviolet light are absorbed by nearby dust and re-emitted as infrared light. The expansion of the universe "redshifts," or stretches, the infrared light into submillimeter waves, which SCUBA can pick up.

The newly discovered galaxies are converting more than 100 solar masses of gas into stars each year. For comparison, the Milky Way Galaxy's rate is only about one solar mass per year.

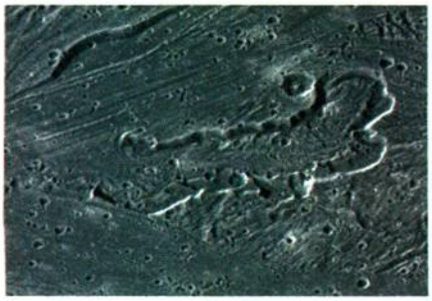
Alternatively, these objects could be dust-enshrouded quasars, superluminous centers of distant galaxies. "The scientists are assuming that they are observing the luminosity associated with star formation rather than the luminosity of quasars," says University of Oregon physicist Gregory Bothun. Bothun notes that a quasar's luminosity would change over a year or two while the luminosity due to young stars would stay the same. Therefore, if the objects maintain their brightnesses, they are most likely galaxies, not quasars. — Rex Graham

GALILEO

Io: Hotter Than Hot

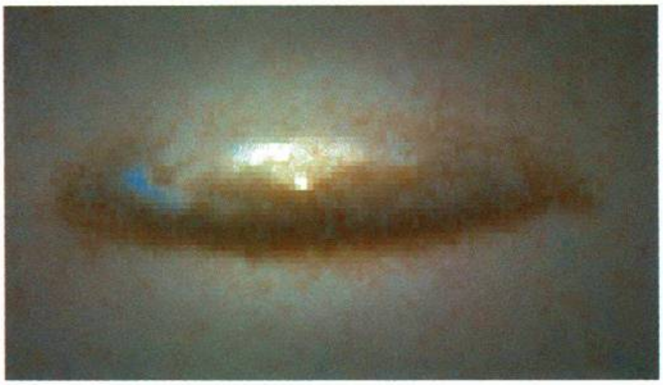
▶ Mercury's sun-scorched craters and Venus's hothouse environment can't hold a candle to the hottest surface in the solar system beyond the sun — the volcanic vents on Jupiter's fiery moon Io. Recent infrared observations by the Galileo spacecraft reveal at least a dozen vents spewing lava at temperatures greater than 2200° F (1200° C), and one as hot as 3100° F (1700° C),

(see "Io," p. 30)



With scalloped walls and internal terraces, this prominent depression on Ganymede appears to be the best evidence for icy volcanism on the jovian moon.

NASA/JPL



This swirling dust ring surrounds a monster black hole in the core of galaxy NGC 7052.

Roeland van der Marel (STScI), Frank van den Bosch (University of Washington), and NASA

BLACK HOLES

Colossal Collision

▶ A giant ring of swirling dust seen in the Hubble Space Telescope image above may be the debris from an ancient galaxy collision. The disk, almost 3,700 light-years in diameter, encircles a monster black hole in the center of the elliptical galaxy NGC 7052, 190 million light-years away in the constellation Vulpecula. The galaxy's core emits a pair of high-speed jets, but because the jets are not perpendicular to the disk, astronomers think the dust and the black hole came from different places. A small neighboring galaxy may have collided with the galaxy after the black hole formed.

The disk appears redder than the rest of the galaxy because dust absorbs blue light better than red — the same reason the sun glows pink on a smoggy evening. The disk's front end appears darker because it eclipses more stars than the back end. Stars crowd around the black hole, creating the bright dot in the center of the galaxy.

While three million sunlike stars could be manufactured from the disk's raw material, the black hole, with the mass of 300 million suns, is gradually swallowing it up. But it will be several billion years before the disk's final demise. — Sarah Simpson

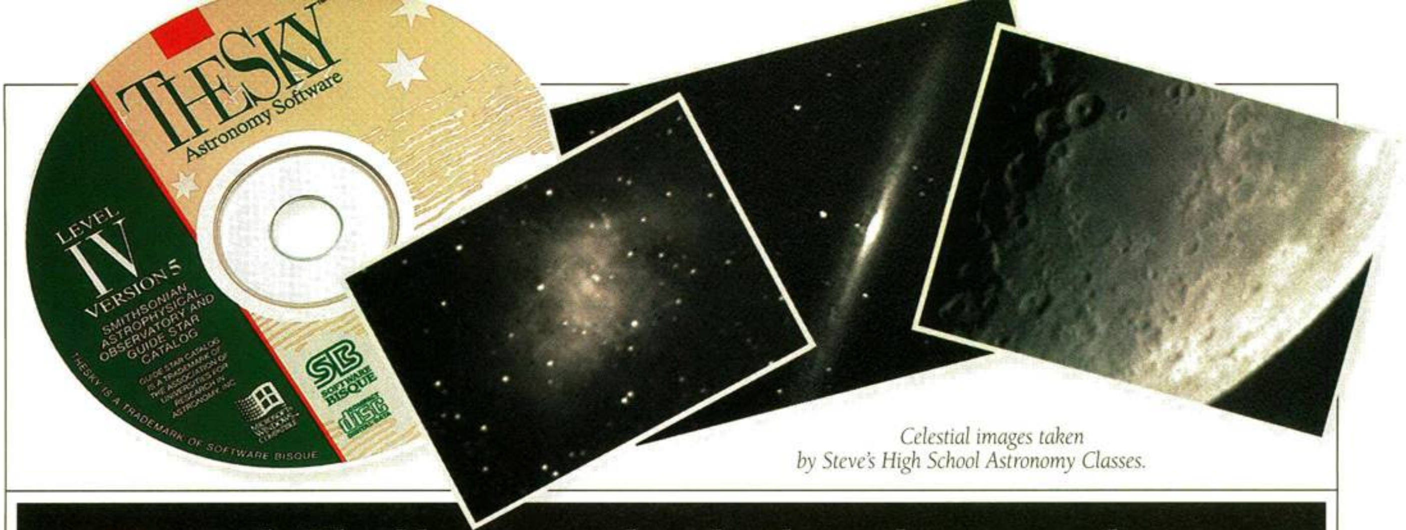
SOLAR SYSTEM

Heat Wave on Triton

▶ A frozen world in space is heating up. Triton, Neptune's largest moon, is undergoing a period of global warming. Although it's a very different world from ours, Triton's warming trend could provide scientists will new insights into Earth's environment.

According to James Elliot of the Massachusetts Institute of Technology, Triton's overall temperature has risen five percent since Voyager 2 flew by in 1989, from –392° F (–236° C) to –389° F (–234° C). "It's a very large increase," he says. "The same change on Earth would amount to 27° F (15° C), raising a freezing

(see "Heat Wave" p. 30)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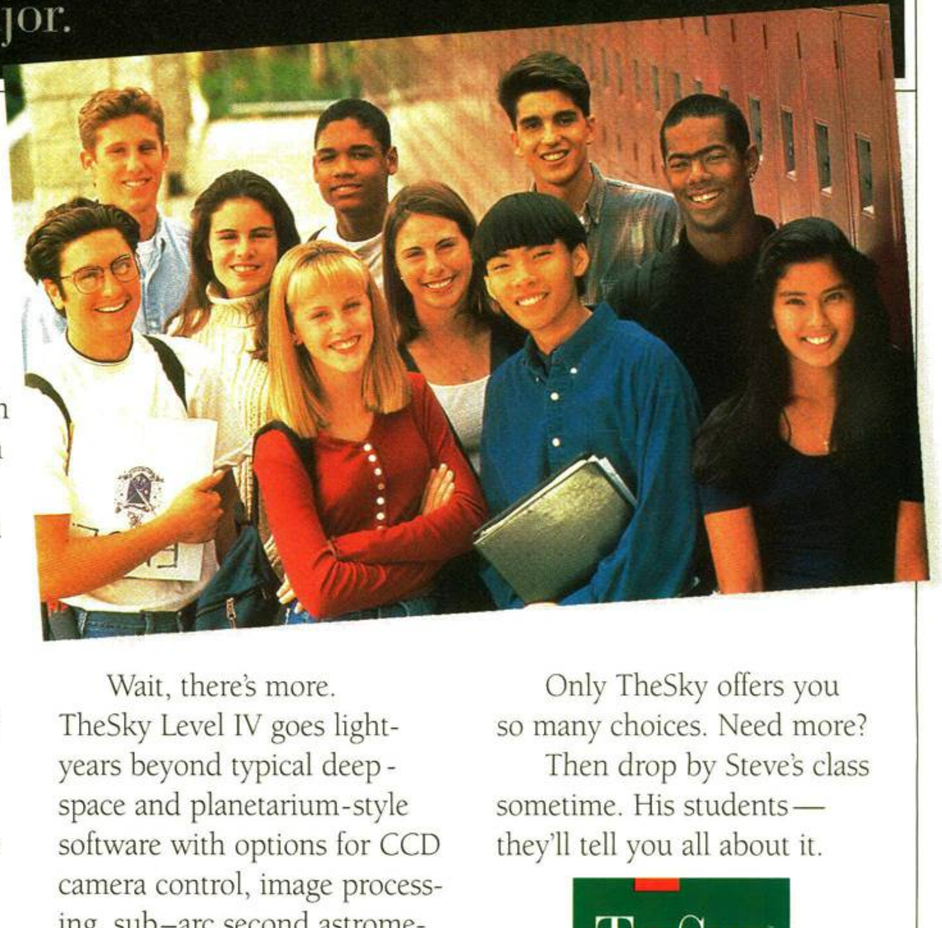

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(Io)

about three times hotter than the temperature on Mercury.

According to team leader Alfred McEwen of the University of Arizona, the temperatures measured are more than double the highest recorded by the Voyager spacecraft in 1979. It's not that Io has warmed up in the past two decades, but Voyager lacked Galileo's sensitivity and wavelength coverage to detect small areas of high temperature. Despite the extreme heat at these hot spots, most of Io's surface remains far below freezing.

The lava's high temperature suggests that it is composed of magnesium-rich silicates. Such dense materials, however, would likely sink in the molten interior, a process called differentiation. "Given Io's intense volcanism, we expect extreme differentiation," says McEwen. "But the evidence suggests we're seeing heavy magma erupt to the surface, as has happened on Earth's moon. How do we explain that?"

The extraordinary volcanic activity on Io is probably not unlike that which occurred on Earth billions of years ago. "Io may ultimately help us to understand the evolution of Earth, Venus, and Mars," says McEwen.

Galileo has also found the best evidence yet that Ganymede, the largest moon in the solar system, has experienced water-ice volcanism. The spacecraft's camera returned an image of a prominent depression about 35 miles (55 km) long and 10 to 12 miles (17 to 20 km) wide. A lobate, flowlike deposit on the floor of the inner depression has ridges that curve outward — and apparently downslope. This structure suggests that a volcanic eruption created a channel and flow, which cut down into the surface.

Not all Galileo news has been rosy. During the July flyby of Europa, one of Galileo's subsystems detected a problem that sent the spacecraft into a "safe" mode, causing the loss of most of the data collected during the flyby. Engineers think the problem arose when debris shorted a signal line. Fortunately, Galileo suffered no lasting damage, and the spacecraft is continuing its two-year extended mission. — RICHARD TALCOTT

(Heat Wave)

temperature of 32° F (0° C) to a balmy 59° F (15° C)."

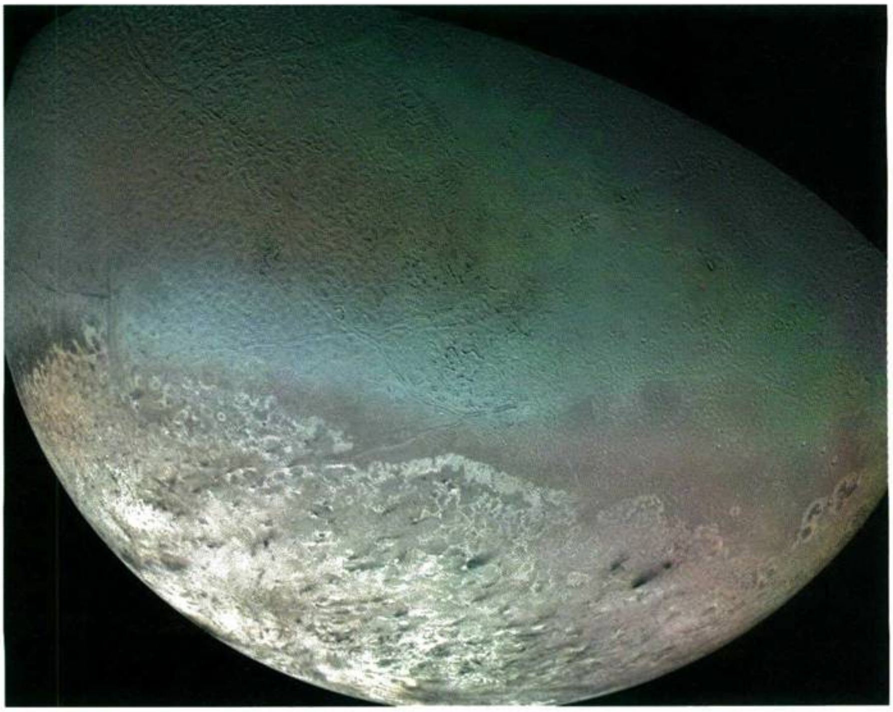
The temperature has increased enough to melt parts of Triton's surface. Made of frozen nitrogen, the surface turns to gas when it thaws, thickening the atmosphere.

One of the three Fine Guidance Sensors aboard the Hubble Space Telescope recorded data that indicated the denser atmosphere. Normally these sensors keep the telescope pointed at a target by fixing on a guide star. In November 1997, one of the sensors was fixed on a star in Sagittarius. Triton passed in front of the star, and the starlight dimmed as it traveled through the thicker atmosphere.

Scientists aren't sure what's causing the warming trend. It could have something to do with Triton's current orbital position. The moon goes around the sun with Neptune every 164 years, but it is also tilted on its axis, and has an unusual orbit around Neptune. "These three periods combine to produce an extreme summer every few hundred years," says Elliot. Right now the sun is highest over the satellite's south pole. But other explanations could also account for Triton's warm spell.

Pinpointing the cause could be important for us. Triton and Earth both share common factors that contribute to global warming: They are affected by the sun's heat output, how much sunlight is absorbed or reflected, and the amount of methane and carbon monoxide in the atmosphere. "If we can understand the case of global warming on Triton and the role, if any, that a change in solar activity plays there, this may lead us to new insights about how changes in solar activity might be affecting Earth," says Elliot.

Elliot and his colleagues published their results in the June 25, 1998 issue of *Nature*. — TRACY STAEDTER



Hubble Space Telescope observations show that Triton (shown in this Voyager 2 image) is experiencing its own version of global warming.

NASA/JPL

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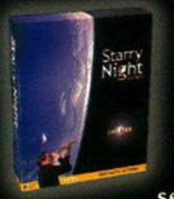

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QUASARS

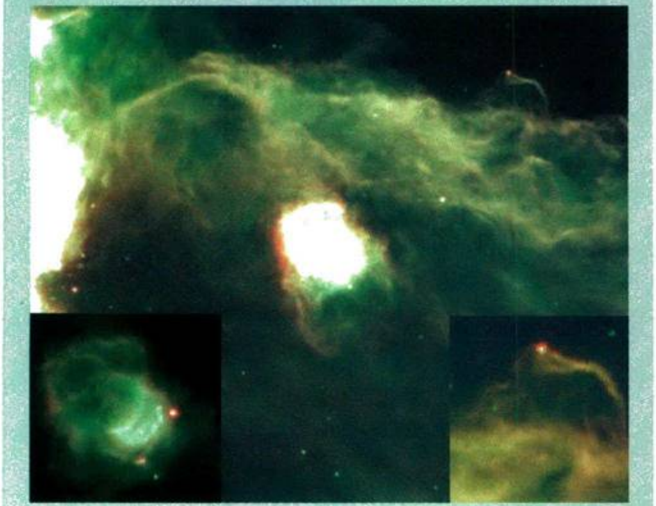
Better Put on Shades

▶ Astronomers have found what appears to be the most luminous continuously emitting object ever seen, a quasar that's about 250 times brighter than typical bright quasars. The quasar lies at a redshift of 3.87, meaning its light has been traveling toward Earth for about 12 billion years. Glowing at magnitude 15.2, it must shine with the luminosity of five million billion suns to be that bright across the vast depths of space.

There's one caveat: The quasar's brightness is probably enhanced by the gravitational lensing of an intervening galaxy. "We estimate that even taking account of gravitational lensing, which probably amplifies the luminosity by a factor of 20, this object

(see "Put on Shades" p. 34)

INFRARED ASTRONOMY



THE HORSE'S NEW HEAD. Even if you've seen billions and billions of pictures of the Horsehead Nebula in Orion, you've probably never seen one quite like these false-color images taken in infrared light. The European Space Agency's Infrared Space Observatory snapped these pictures before the satellite went defunct in May 1998. The one-light-year-long Horsehead appears dark in visible light, but in infrared, it almost disappears as it's swamped by the bright glow of the surrounding gas and dust. ESA/ISO/ISOCAM Team and L. Nordh (Stockholm Observatory), et al.

THE MOON

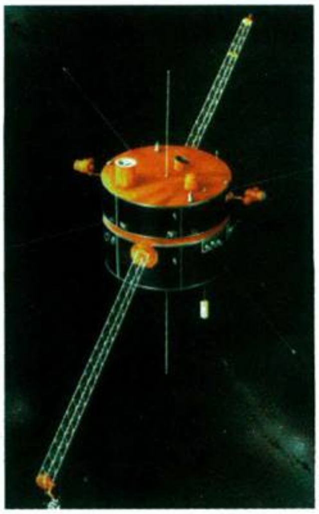
Getting WIND of the Moon's Atmosphere

▶ By conventional standards, the moon has no atmosphere. It has no clouds, no weather, no smog alerts. But the moon is surrounded by a tenuous mist of particles, an "atmosphere" that is about 100 trillion times less dense than Earth's atmosphere. Scientists led by Urs Mall and Erhard Kirsch of the Max-Planck-Institute for Aeronomy in Katlenburg-Lindau, Germany, have recently found a new constituent of the lunar atmosphere: charged atoms (ions) of oxygen, silicon, and aluminum.

The team observed the moon's atmosphere using the Suprathermal Ion Composition Spectrometer (STICS) instrument aboard NASA's WIND spacecraft, which was launched in 1994. STICS detects atoms kicked up from the lunar surface by the solar wind in a process called sputtering.

Once sputtered, these atoms are exposed to ultraviolet radiation from the sun. The radiation whacks out an electron from an atom, giving the atom an electrical charge. STICS measured these charged particles as WIND flew by the moon 17 times between 1995 and 1997.

Team member George Gloeckler of the University of Maryland, who is STICS's principal investigator, emphasizes that STICS provides a direct means for analyzing the composition of the lunar atmosphere. Previous Earth-based observations analyzed the spectrum of moonlight to acquire information about the atoms present. In 1988, these kinds of observations detected sodium and potassium in the lunar atmosphere. Other studies, including those based on the Apollo missions, found traces of helium and argon.



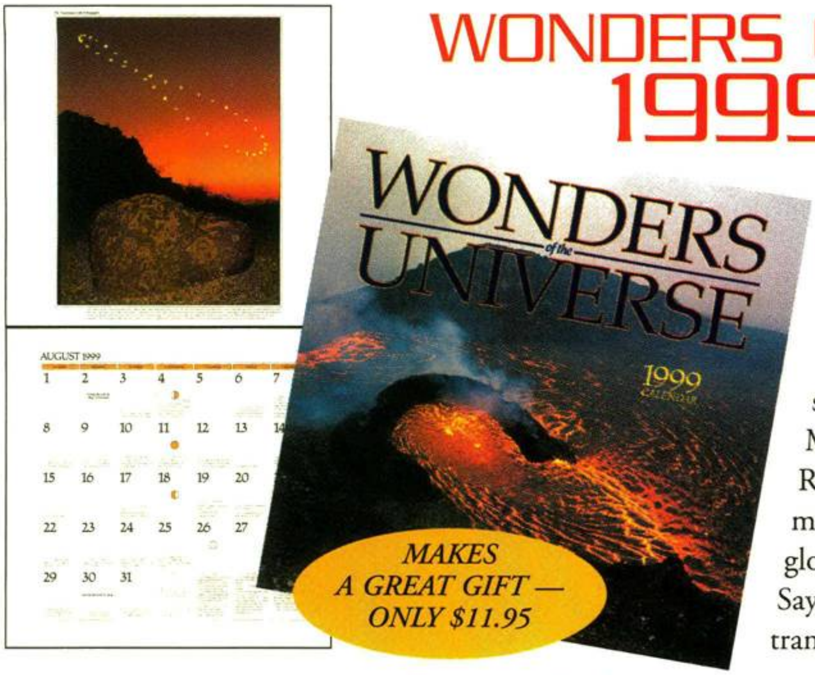
NASA

An instrument aboard NASA's WIND spacecraft detected three new elements in the moon's tenuous atmosphere.

But these particles don't add up to much. "The measurements — Apollo and ground — account for only 10 percent of what makes up the lunar atmosphere," says team member Antoinette Galvin of the University of New Hampshire. To find the remaining constituents, the team will rely on computer modeling and more WIND flybys. The results will provide more clues about airless planets, such as Mercury, and other objects.

WEBSITE

Check *Astronomy*'s website for news as it happens — http://www.astronomy.com.



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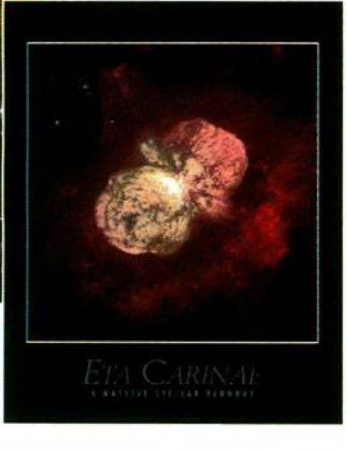

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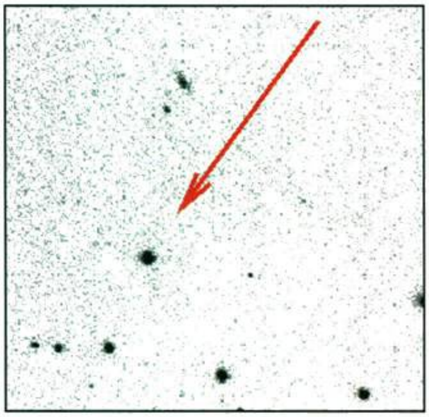
(Put on Shades)

is still one of the brightest, if not the brightest, objects currently known," says Mike Irwin of the Royal Greenwich Observatory in England.

The image was taken on February 28, 1998, with the 0.9-meter Jacobus Kapteyn Telescope on the island of La Palma in the Canary Islands.



The arrowed dot in this image might not look like anything to write home about, but it could be the brightest continuously emitting object ever observed. Mike Irwin (RGO), Rodrigo Ibata (ESO), et al.

MARS MISSIONS

MATCHED PAIR. The Japanese Mars-bound spacecraft Planet-B (later renamed Nozomi, for "hope") snapped this lovely image of the Earth and moon on July 18, two weeks after its launch from the Kagoshima Space Center on the island of Kyushu. Planet-B took the image from its elliptical orbit around Earth. In December 1998, the spacecraft will leave the confines of Earth orbit and head toward an October 1999 rendezvous with Mars. To learn more about the mission, go to http://webserver.gsfc.nasa.gov/Code915/planetb.html. ISAS

SOHO under Control

On September 16, engineers regained control over the wayward Solar and Heliospheric Observatory (SOHO) by sending commands that keep the spacecraft's solar panels pointed toward the sun. "It's a big step forward in our recovery plan for SOHO," says John Credland of the European Space Agency. Controllers lost contact with SOHO on June 24. Radio contact was re-established on August 3, but SOHO was still tumbling out of control. At press time, it was unknown what damage had been done to SOHO's 12 scientific instruments.

Subaru to Open Soon

Contraves Brashear Systems of Pittsburgh, Penn., has just finished figuring and polishing the Subaru Telescope's 8.3-meter mirror. The National Astronomical Observatory of Japan will operate the telescope, which is currently under construction on the summit of Mauna Kea on Hawaii. The Subaru mirror is the world's largest single-piece mirror. The 8-inch thick, 24-ton mirror's surface is so smooth that if it were the size of Hawaii, the largest "hills" and "valleys" would be the thickness of a sheet of paper. The mirror will be attached to the telescope in January 1999.

The Subaru Telescope's 8.3-meter mirror is now the world's largest that comes in one piece. Contraves Brashear Systems

Sojourner's Successors

Of all Mars Pathfinder's accomplishments, nothing enthralled the public more than the rover Sojourner. Now it appears that a spare built for the Pathfinder mission, Marie Curie, will be heading to Mars in 2001. NASA originally planned to send a larger and more sophisticated rover to Mars in 2001, but budgetary and time pressures led to the scaleback. The larger rover, Athena, has been rescheduled for a 2003 launch.

When the World Is Running Down

The New Year won't arrive as quickly as usual this year. Timekeepers are adding an extra second to the end of 1998 to make up for the gradual slowing of Earth's rotation. Although Earth makes an excellent clock for everyday living, in this age of atomic clocks, Earth just isn't up to snuff, so "leap seconds" need to be added occasionally to keep the two systems in sync.

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M51 Whirlpool Galaxy. *The first galaxy found to have spiral structure is about 35 million light years distant and about 10 arc minutes in apparent diameter. This five-minute ST-5C exposure was taken in moderate light pollution with a Celestron C8 reduced to f/4 using the ST-5C focal reducer. Courtesy Alan Holmes and Michael Barber / SBIG.*

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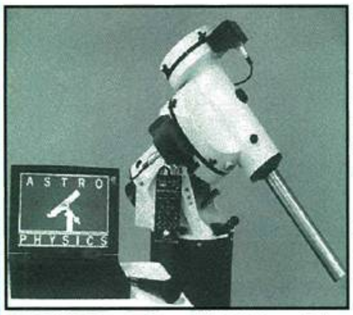

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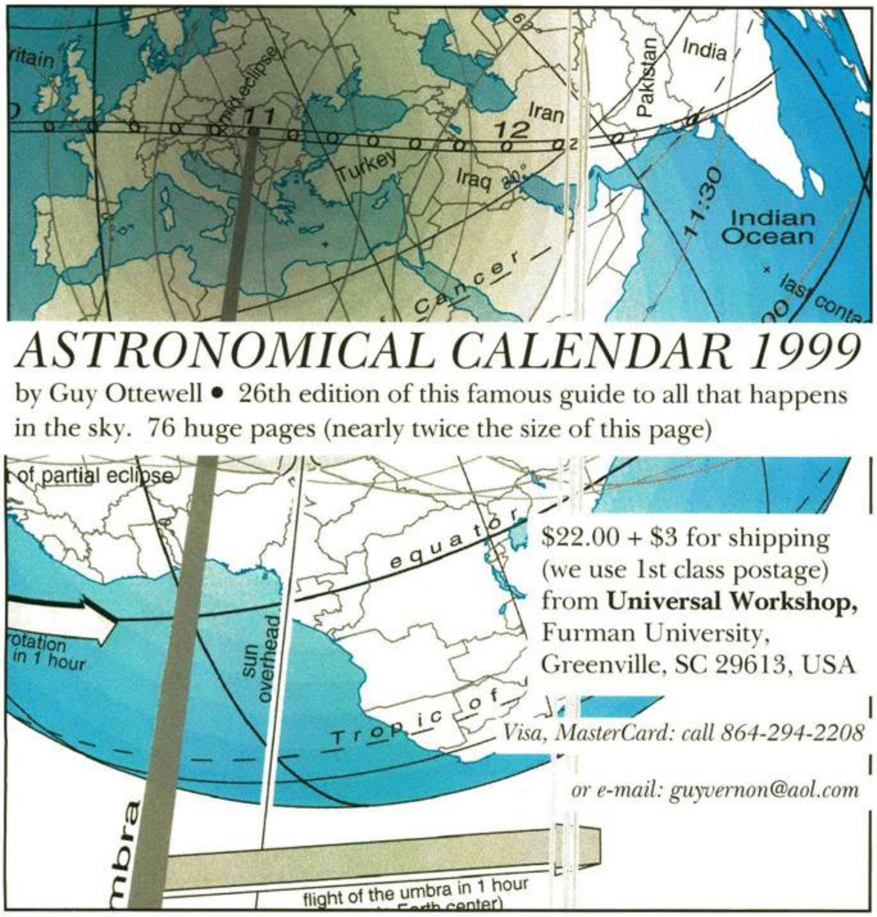
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11:30
Indian Ocean
Cancer
last conta
of partial eclipse
equator
rotation in 1 hour
sun overhead
Tropic of
mbra
flight of the umbra in 1 hour

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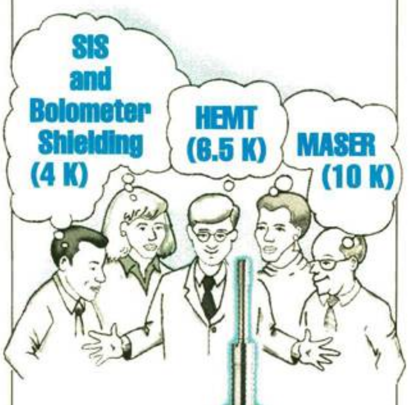
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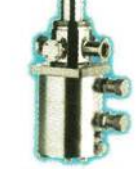

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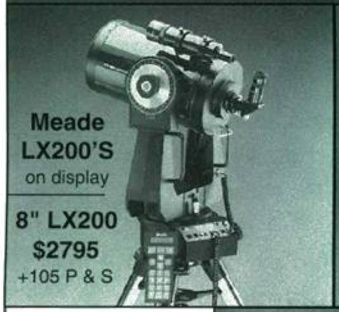

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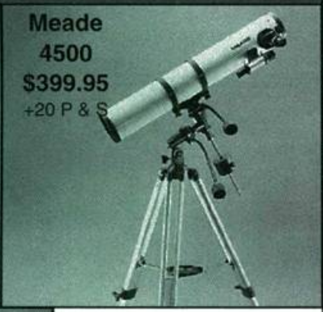

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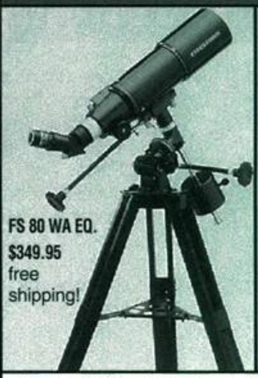

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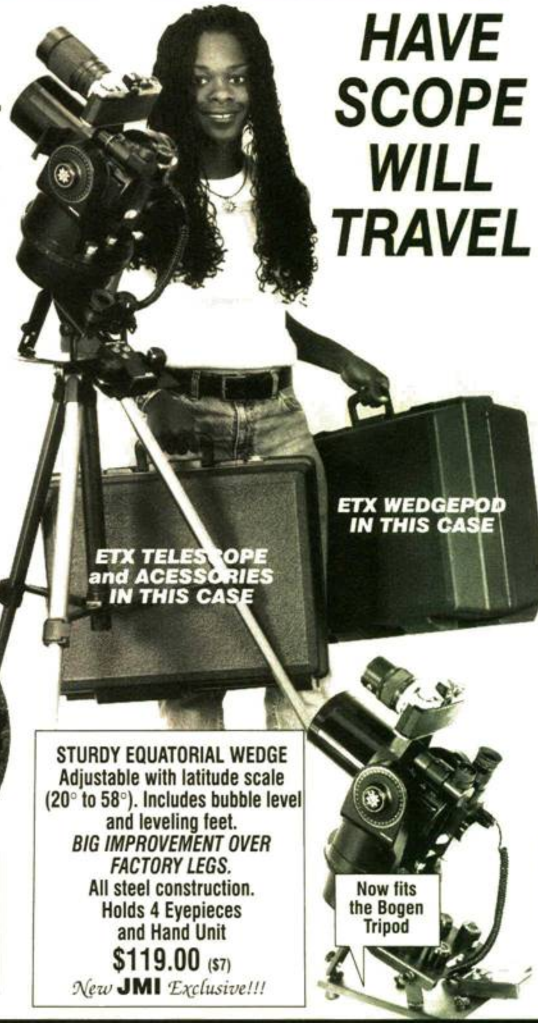
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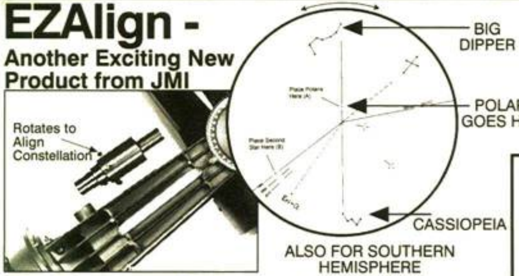

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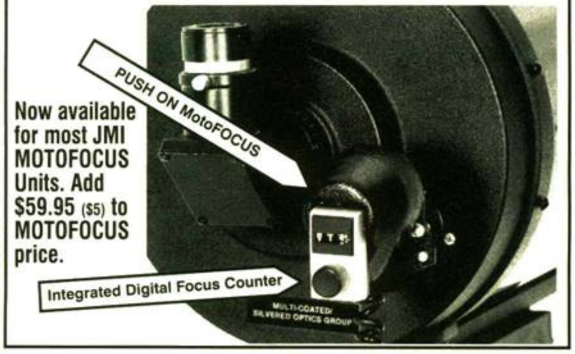
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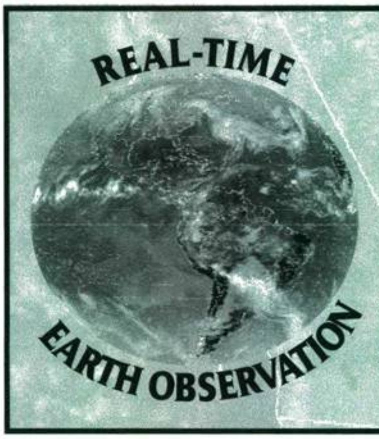

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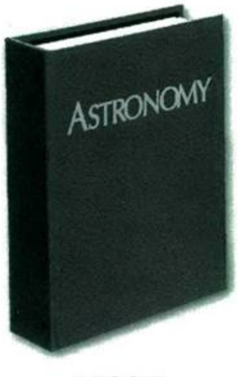

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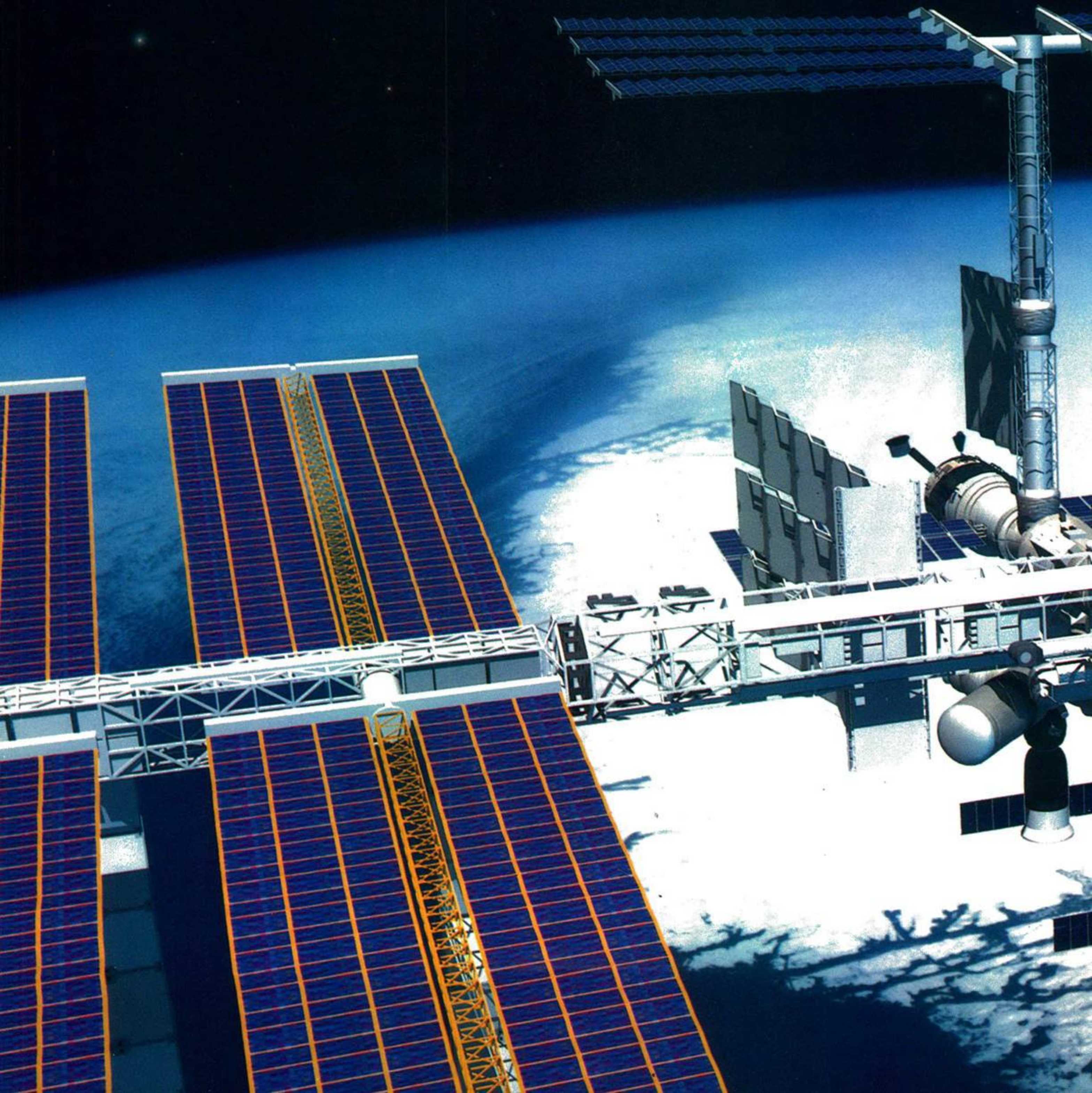

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Space

by Andrew Lawler

FORGET THE ELEGANT WHEEL-SHAPED CRAFT FROM *2001: A Space Odyssey*. The International Space Station will look like a flying trailer park when space walking astronauts finish assembling it. Awkward metal trusses will connect utilitarian, pressurized, barrel-like modules to ungainly, winged solar panels that will convert sunlight into electricity.

Six-astronaut crews will have priceless views 200 miles above Earth aboard this ultimate mobile home. Critics may attack it as pork-barrel space junk, but the space station will be the single largest international scientific and technological effort ever undertaken in peacetime. However, the drumbeat of criticism is unlikely to fade even if astronauts finish it on schedule in 2004. This timetable, while optimistic, means the station will be a decade late and cost tens of billions of dollars more than originally conceived. Total cost estimates range from $40 billion to more than $100 billion. However, NASA managers proudly assert that it will mark a milestone in the human push to explore and live beyond the planet.

Space-station partners hope to capture the world's imagination with the first of what will be dozens of assembly and maintenance launches. It is more than a testing ground for future missions to Mars: It is a scientific United Nations and a milestone of scientific, technological, and political ingenuity of the highest order. That is if the partners can pull it off. Unfortunately, Russia can't deliver the Service Module, its primary contribution, in time for its planned April 1999 launch. NASA wants Congress to give Moscow a $660 million bailout over five years. The partners are Japan, Canada, Belgium, Denmark, France, Germany, Italy, the Netherlands, Norway, Spain, Sweden, Switzerland, and the United Kingdom.

Voodoo Science

President Ronald Reagan championed the space-station idea in his 1984 State of the Union address. The critics say the project's 15-year history is a testament to political creativity, not scientific achievement. "Its goals are political, not scientific," says Robert Park, a longtime station opponent who works for the American Physical Society.

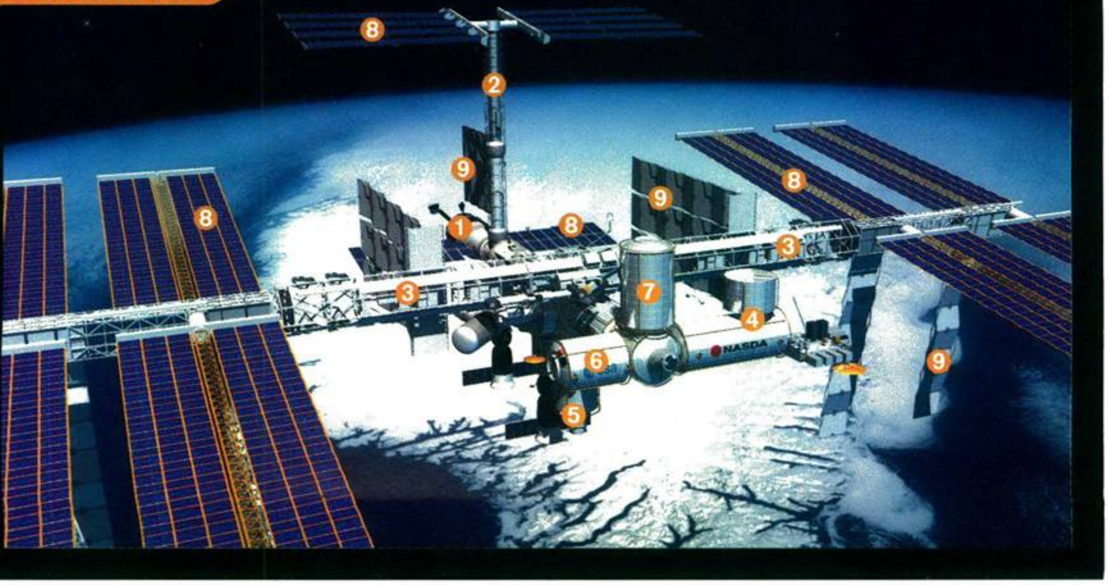
Park and many other scientists wish the space-station money was being spent on productive, inexpensive planetary science missions. They complain that there is little evidence that the station will benefit life and materials sciences. Park rebuffs claims made by lawmakers during funding feuds that the program will help find cures for diseases and result in exotic new materials. "It's simply not good to promise things that will not happen," he says. "This is clearly voodoo science."

Reagan's NASA Administrator James Beggs realized that the freshly minted space shuttles could have an important assignment — help build the space station.

Nobody disputes that research is not the real reason for the space station; otherwise it never would have survived, says a coterie of Washington observers. "It's not a science project — it's a foreign policy initiative," says John Pike, an analyst with the Federation of American Scientists who has watched the program closely. "For Reagan it was to whip the Evil Empire; for Clinton it is to be friends with the Russians." It also has provided thousands of jobs to American aerospace workers from California to Florida, and those jobs amount to political muscle.

In the early 1980s, aerospace money began pouring into the Pentagon and Southern California's aerospace industry. NASA's new administrator at the time, James Beggs, saw an opportunity for his agency to win approval for an expensive new program that would give the freshly minted space shuttles something to do. Beggs knew NASA needed to sell the idea and he knew the potential buyers. Scientists wanted a research platform in the weightlessness of space. Eager aerospace contractors wanted federal money. Congressional

STATION ASSEMBLY SCHEDULE



Some of the major components of the International Space Station are numbered in this artist's concept as an assembly and flight-date guide for individual modules pictured on pages 54 through 59. The dates of the flights were set by NASA. (All images: National Aeronautics and Space Administration.)

Assembling the Puzzle

The International Space Station is not like a snap-together Lego or Tinker Toy set. It is a complicated, one-million-pound jigsaw puzzle. It will consist of tubes, girders, cables, and delicate, wing-like solar panels. Workers in Moscow, Los Angeles, Turin, Nagoya, and a dozen other cities are making most of the pieces. For the first time, astronauts will connect many of the parts in space without benefit of prior ground trials. Outfitted in bulky space suits, wearing fat, cumbersome gloves, they will fasten, weld, and tie the components together as they space walk above Earth.

United States' space shuttles, European Ariane rockets, Japanese launchers, and Russian Soyuz vehicles will relay astronauts and deliver the space-station components in more than 50 flights. An additional 30 flights will provide fuel, food, and other supplies during construction. "Think of the sheer magnitude of it," says Joe Rothenberg, NASA's soft-spoken and bespectacled space flight chief. "There are some 60 major pieces and it can't be assembled first on the ground and tested."

It will not be easy. Rothenberg oversaw the dramatic Hubble Space Telescope repair mission that corrected the effects of that telescope's improperly made and inadequately tested primary mirror. "On the Hubble mission we pretty much knew what to expect, but with the space station, astronauts will have to be able to fix a variety of problems on the spot," says Rothenberg.

The first United States-made pieces began dribbling in to the Kennedy Space Station Processing Facility in Florida this past spring in preparation for launch. The first step in the assembly plan is to send up the Russian-made, *20-ton module* that contains electronic equipment, fuel, and control systems. Next, a shuttle will deliver a small round node that will serve as a construction shack. Astronauts will attach larger modules to it. Later, they will attach a truss and solar panels to juice up the nascent station's electrical systems.

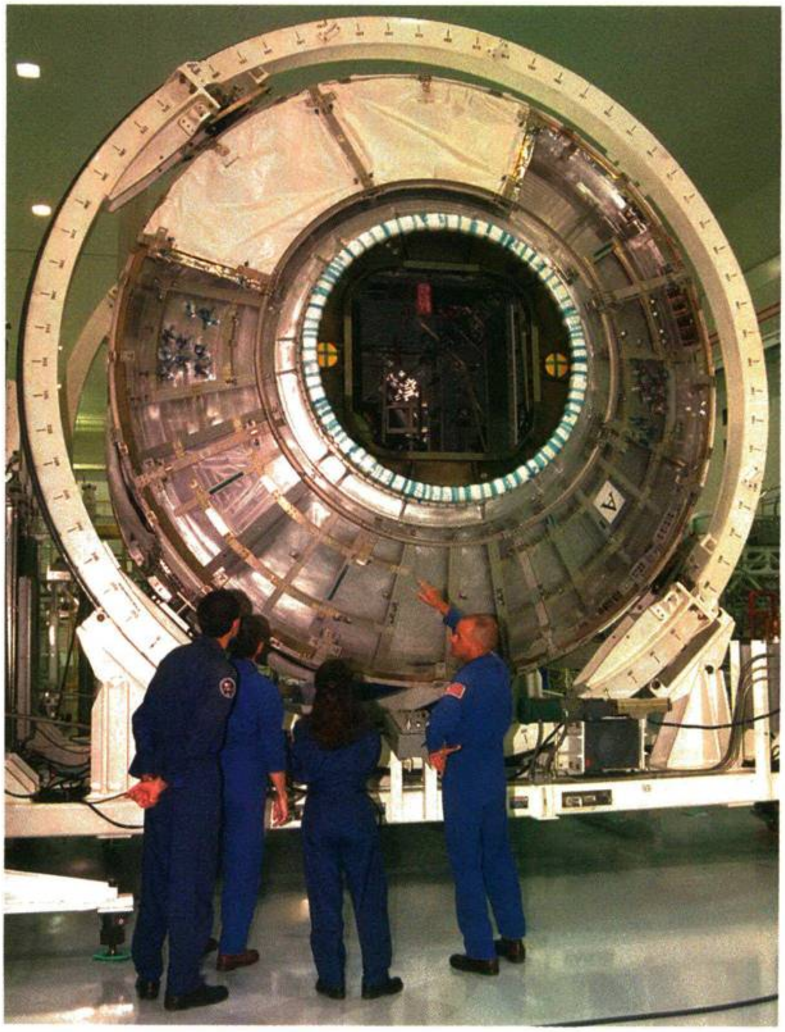
At this point, astronauts will attach the service module – a large structure designed to house the early station's control and support equipment. This module is the centerpiece of Russia's contribution. The Russian government's chronic lack of money led to delays in the completion of the module, but NASA officials hope it will be ready for launch by the summer of 1999.

Astronauts will attach the United States' laboratory, the centerpiece of the American program, after they add more solar panels. Next, crew members will add United States and Canadian robotic arms, airlocks, and eventually the United States' habitation module. Early next century they will attach a lab built by the European Space Agency and another built by Japan, completing the station. The assembly will take at least five years, barring a disaster. (A launch failure could set the program back months or years.)

Compared to the cramped and aging Russian Space Station, Mir, the new space station will be a luxurious campus. Astronauts will gather for meals around a table, sleep in compact but private crew quarters, shower, and occasionally "walk" outside. They will work in half a dozen other modules conducting experiments and performing maintenance.

The United States will own half the real estate, including the laboratory module, the sleeping quarters, and three smaller cylinders called nodes that will connect the modules. NASA also will own a 20-ton control module built by a private Russian company.

The Russian government is providing two research modules, a critical service module with life support systems, and transport vehicles to carry supplies and dispose of trash. Japan and Europe are building their own scientific modules, along with transport vehicles. But given the political and financial turmoil in Russia, there are doubts that the world's first spacefaring nation will be able to fulfill its promises. –A. L.



Space-shuttle mission specialist Jim Newman, left, commander Bob Cabana, mission specialist Nancy Currie, and pilot Rick Sturckow inspect Node 1, which will function as a connecting passageway in the space station.

1] FLIGHT 1R – 1999

The Service Module is a living quarters and the primary Russian contribution to the station. It contains a propulsion system to move and properly orient the orbiting station, and it is the primary docking port for resupply vehicles.

incumbents, facing re-election, wanted research and development dollars for their states and districts. The State Department wanted a way to strengthen United States' strategic alliances and counter the Soviet threat. Allies of the United States wanted to join the exclusive club of nations able to send humans to space. Engineers wanted to play in the ultimate playground, and space enthusiasts were eager for a new adventure.

Beggs methodically gathered his allies under the space-station umbrella. This was not to be an impulsive dash like the Apollo missions to the moon in the 1960s and '70s. This was not to be the mere half a loaf that President Richard Nixon offered NASA in the 1970s after he rejected the space station and approved a scaled back shuttle. Instead, the station was a carefully calculated effort to win political backing for an expensive project that garnered little enthusiasm elsewhere in the government.

It almost failed. At a heated White House Cabinet meeting on a cold winter day in 1983, Beggs found himself under attack by Caspar Weinberger. The Defense Secretary feared the project would cost far more than the $8 billion Beggs had estimated. Weinberger worried it would eat into defense spending. At some point during the meeting, Reagan winked at the NASA administrator, a sign that he should not worry about the carpers.

A few weeks later on national television, in words reminiscent of President John Kennedy's 1961 call for a moon landing, Reagan urged the nation to build the space station in one decade. It was to be America's high-technology answer to the Russian space station, which by then had been in orbit for several years. The space station also was a way to cooperate with allies of the United States that were nervous about the hawkish Reagan. "It was the Cold War that kept it going in the 1980s," says Joe Rothenberg, NASA's new space flight chief.

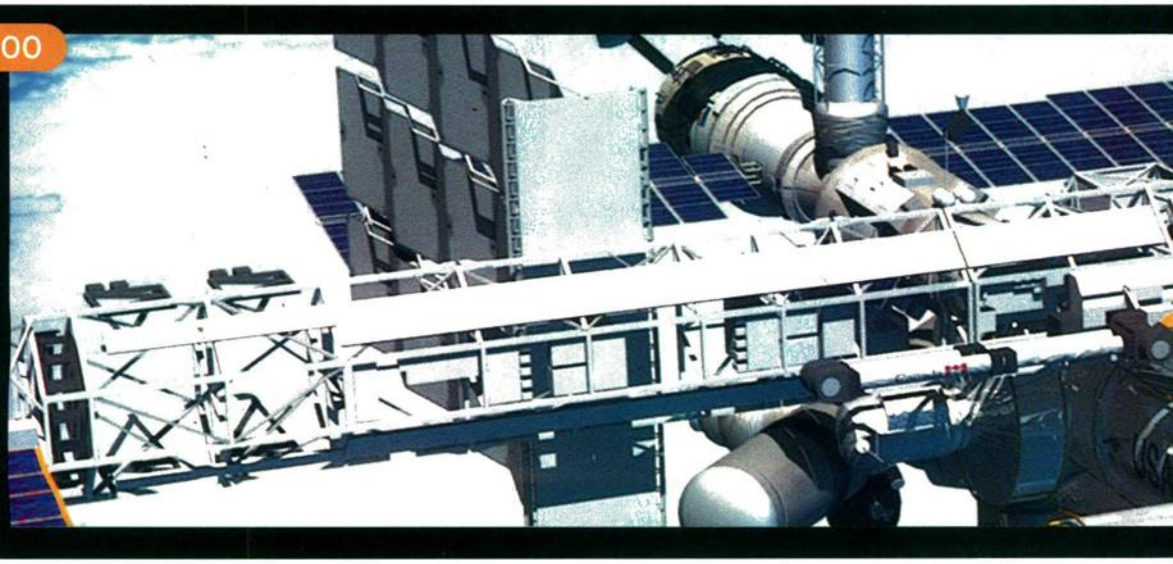
Space-station dollars flowed into 42 states. "In the 1980s, jobs were the primary driver," says Bill Smith, a former Democratic staffer in the House of Representatives. Most of those jobs were in politically powerful areas in California, Florida, and Texas. Lobbyists from McDonnell Douglas, Rockwell, General Electric, and Grumman cruised the halls of Congress, keeping tabs on the "economic impact" of the program. That pressure helped supporters overcome yearly attempts by critics to cancel the project in Congress.

Tough Sledding

By the turn of the decade, the United States already had spent nearly $8 billion on the project. (Reagan dubbed it Freedom to underscore its challenge to the Soviet political system.) However, the Challenger explosion in 1986 and the resulting fiery death of the five-man, two-woman crew prompted upheavals in NASA's management. Members of Congress quibbled over the station's design, and contractor squabbles slowed the project. As a result, costs soared. "It became, as one NASA manager put it at the time, a self-eating watermelon," recalls Adam Gruen, a historian paid by NASA to write the inside story of the program. "When it takes you 12 months to delay the schedule by 10 months, that's tough sledding."

The second crisis was the breakup of the Soviet Union. It came as American budget deficits pinched domestic spending and squeezed NASA's budget. At the same time, costs to

3] FLIGHT 8A – 2000



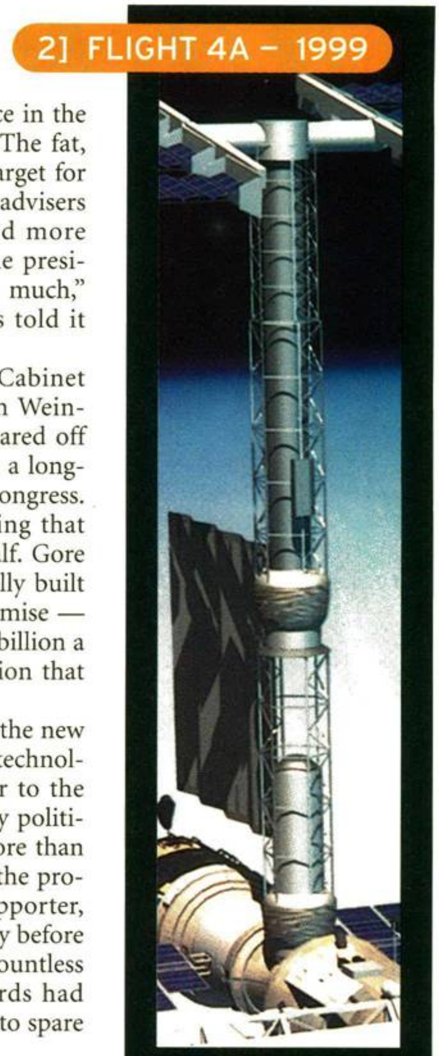
Astronauts will attach the central-truss segment to the United States' laboratory. The truss segment will be the kingpin of the 300-foot Integrated Truss Structure. Astronauts will attach four additional starboard truss segments and three port segments later.

complete the space station had doubled to nearly $14 billion since the Challenger disaster. In 1993, with the Soviet threat gone, the space station coalition began to unravel. Bill Clinton took up residence in the White House amid talk of massive cost overruns. The fat, expensive, slow-moving space station was an easy target for budget cutters. The new president and his science advisers appeared to favor faster-paced efforts that could more quickly benefit United States competitiveness. "The president needed to know why the space station cost so much," one former White House official recalls. "He was told it needed a brain transplant."

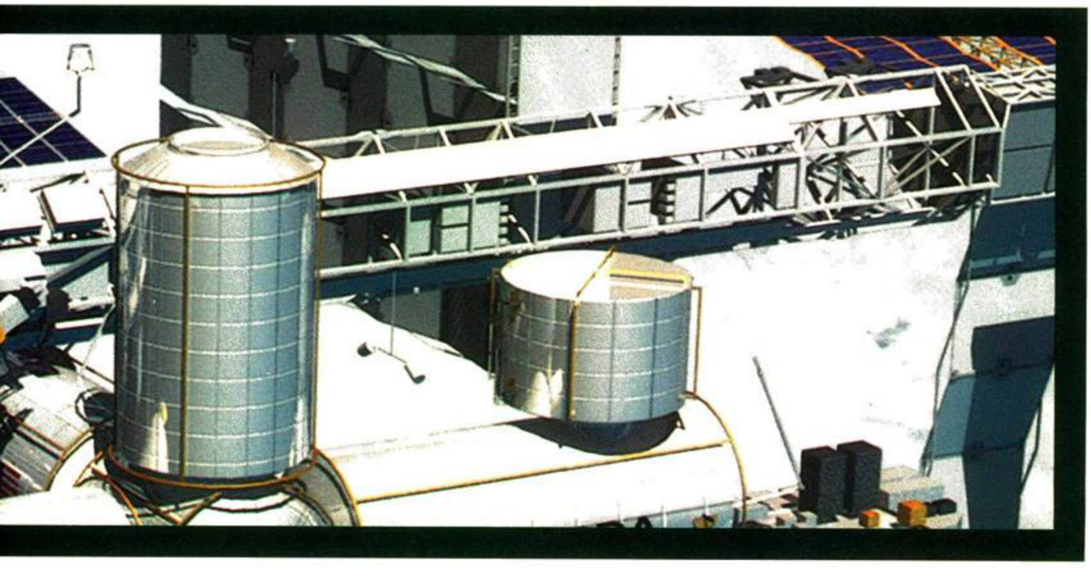
With Clinton's election, the faces around the Cabinet table had changed. Instead of Beggs sparring with Weinberger, Vice President and technophile Al Gore squared off against White House Budget Director Leon Panetta, a long-time station opponent while he was a member of Congress. Panetta argued in a February 1993 Cabinet meeting that Clinton should cut the space station's budget by half. Gore knew such a blow would ruin the program's carefully built constituency. Gore and Panetta agreed to a compromise — NASA would cap space-station expenditures at $2.1 billion a year, redesign the project, and present the new option that summer to Clinton.

Clinton's advisors met again in June to look over the new plan. Clinton talked about the need for science and technology investment. However, in private sessions prior to the gathering, his advisers say he worried about the ugly political fallout of canceling the station. By that time, more than 15,000 American workers in 42 states depended on the program for their livelihoods. A key space-station supporter, Texas Governor Ann Richards, visited Clinton the day before the space-station meeting at the White House. In countless phone calls during the preceding months, Richards had badgered the president. She desperately wanted him to spare the project, White House aides recall.

There was more than jobs at stake. Clinton's NASA Administrator, Daniel Goldin, urged United States and Russian officials to discuss the merger of Russia's Mir 2 with the space station. The appealing new objective catapulted the space station beyond mere jobs and science. Clinton gave the green light to revamp Reagan's space station and proceed.


2] FLIGHT 4A – 1999

The Integrated Truss Structure will provide cooling radiators, a communications system, and power with its solar arrays and batteries.



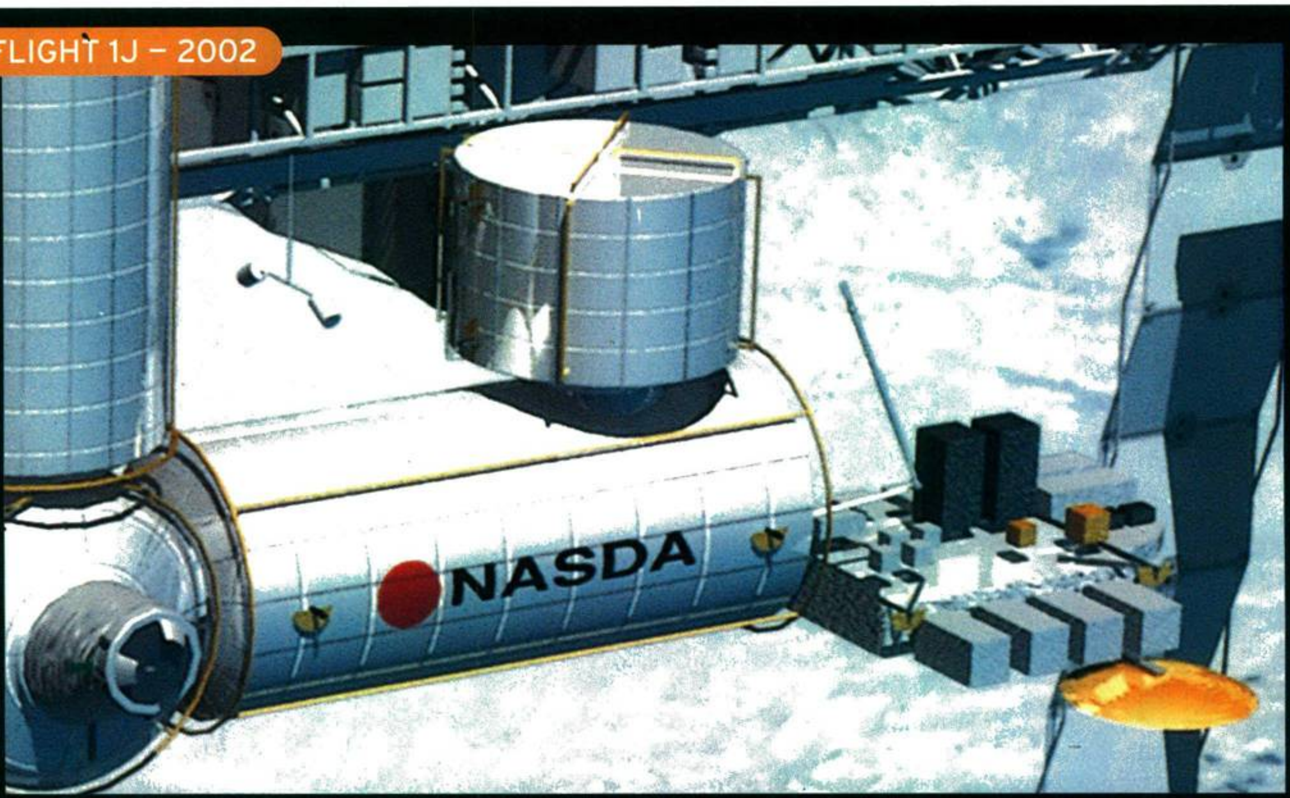
Pitching the Station

"You're looking at the future," says the NASA guide to dozens of visitors dressed in shorts and T-shirts. I squint through glass and look downward. In this vast building at Kennedy Space Center in Florida, powder-blue-suited men and women walk like ants on the spotless floor among pieces of the International Space Station. Ironically, most of these visitors are here because of a glitch: NASA scrubbed today's shuttle launch. This excursion transforms disappointment into awe.

In 2004, astronauts are scheduled to finish connecting a gangly collection of tank-like pods, metal frames, and solar panels. The result will occupy the volume of a major-league baseball park. Our guide pitches the future benefits of the space station and tells us to anticipate the first launch in June 1998. (That launch date, doubtful at the time, later was delayed for months.) He then asks us to leave through a side door so another group of visitors can enter.

I gawk a moment longer from our box-seat, plate-glass vantage point high above workers assembling pieces of white hardware. I ask the guide if he is aware that the first launch almost certainly will not happen before late fall. He shrugs. The future as described by NASA sometimes takes longer than promised to arrive. –A. L.

4] FLIGHT 1J – 2002



The primary Japanese contribution to the station is the Japanese Experiment Module. Its robotic arm will tend experiments on the laboratory's adjacent "back porch," or Exposed Facility.

A Black Hole

That decision was nearly a Pyrrhic victory for program supporters. Armed with the cost overruns and emboldened by months of White House ambivalence, congressional critics attacked a few days later. The program's bête noire, Indiana Democratic Representative Tim Roemer, compared the program to "a black hole quickly sucking away money from other promising scientific projects." He argued that NASA had mismanaged the effort and that there was no sane reason to put humans into orbit. House lawmakers came within a single vote of canceling the program.

NASA and White House officials realized that jobs and rhetoric about technological leadership were no longer enough to save the program. Goldin found a new purpose for it. He understood the powerful symbolism of joining two old enemies in a high-tech project. There also was growing concern that thousands of poverty-stricken Russian scientists and engineers might design missiles and bombs for Iran or Iraq. The United States and Russia, Goldin argued, were already cooperating in their shuttle and Mir programs — why not extend that venture to the space station?

It worked. White House officials embraced the idea that the space station could be a strategic corner in national-security policy. The annual budget cap of $2.1 billion defused criticisms of its accelerating cost. NASA set up a permanent "war room" on the seventh floor of its Washington headquarters building, a short walk from the Capitol, to manage the fight to save the station. Roemer and fellow longtime opponent, Democratic Senator Dale Bumpers of Arkansas, lost the upper hand.

Cost Savings Vanish

However, promises of cost savings never materialized. Delays again set in, and Russian participation became a financial burden. This spring, an independent audit revealed that the program would cost as much as $7 billion more than NASA estimates and take up to three more years to complete. Boeing, which took over in the early 1990s as the prime contractor, has had difficulty controlling the costs of the hundreds of suppliers and subcontractors. Meanwhile, the $2 billion that Goldin estimated would be saved with Russia as a partner vanished.

"We must get this program under control," thundered Jim Sensenbrenner, the Wisconsin Republican who chairs the House Science Committee, in a recent hearing. Roemer cited the report as proof that the space station was beset by budgetary overruns and massive scheduling problems. "The more daylight that shines on this program, the darker the outlook for its successful completion," he said.

Somehow, Sensenbrenner's and Roemer's criticisms seem to bounce off NASA officials, who know that the president and most lawmakers support the program. The program, says former White House Office of Management and Budget chief Franklin Raines, "is bound to face technical, cost, and scheduling challenges." White House officials say privately they don't know how they will come up with the extra money to fund the space station. Researchers who depend on NASA funding worry that the Clinton administration eventually will cut science projects to pay for the overruns. Already, NASA has postponed construction of key scientific facilities aboard the station in order to pay for building hardware. The agency's other space-science efforts, like robotic missions to Mars and a program to monitor Earth's environment, are in danger, Park and others warn.

The Right Stuff

NASA's space-station chief Randy Brinkley, Rothenberg, and other NASA officials say the threat to scientific research would be greater without the space station. They argue that the more money NASA has received for human space missions, the more it also has received for science overall. However, critics like Park dispute that argument. The Pathfinder mission to Mars last year captured the public's attention for weeks, and the bread-box-sized Sojourner rover became a media star. Newspapers published obituaries in observance of Sojourner's passing. "NASA hopes the space station will recapture the imagination of Americans and bring back the days when we crowded around our living

5] FLIGHT 20A – 2002

Node 3 will contain avionics and life-support equipment. The node will be the attachment point for the United States Habitation Module, the crew-return vehicle, and other additions.

Biggest, Best, Costliest

It is difficult to be straight-faced and unimpressed. The 457,000-square-foot, white-painted Space Station Processing Facility hangar, trimmed in red steel beams, soars 10 stories above the swaying marsh grasses and scrubby mangroves of Florida's coastal wetlands. The Kennedy Space Center building bristles with metal cranes and national pride. As workers piece together the many parts of the soon-to-be-orbiting International Space Station, visitors jostle in an adjacent building to see a mockup of a training lab used by Apollo astronauts.

The space station's stated goal is to improve humanity's quality of life through international research and good will. Here, in this publicly funded oasis of technology, the future appears to be well in hand.

The influence of Disney World in nearby Orlando, Florida, also seems to have spilled over to Kennedy where workers are painstakingly assembling NASA's Tomorrow Land. However, this will be no amusement-park ride. This will be the largest, most expensive, and most complicated international scientific and engineering project ever built. The project already has consumed 15 years and billions of dollars, rubles, marks, and yen. It somehow has endured changes of government, currency fluctuations, and funding crises from Moscow to Paris. Key members of the Clinton administration once tried to cancel it and members of Congress bitterly attacked it – unsuccessfully.

The space station's improbable ride of political twists, technical leaps, and diplomatic dips surpasses the loops and curves of the rides at Disney World's Space Mountain. The space station's appeal is so multifarious it can contain conspicuous contradictions. It is a Cold War relic that depends on Russia. It is a scientific mega-project dismissed by many researchers as an utter waste of money. Even though NASA has otherwise dedicated itself to faster, better, and cheaper missions, the survival of the bloated, over-budget, and behind-schedule space station suggests that biggest is best.

The project fulfills our desire to establish the first international colony in space, but fatalistic critics call it an unstoppable political steamroller. "We are not going to kill the space station," a longtime opponent, Democratic Senator Dale Bumpers of Arkansas, told NASA Administrator Daniel Goldin at a recent Senate hearing. "You have nothing to fear." –A. L.

Technicians examine one of the eight solar arrays that will be delivered to the orbiting space station. This array actually is only half of a single 38-foot by 108-foot solar panel.

room TVs to watch Neil Armstrong," says Roemer. But it was Pathfinder, not a human mission, that drew crowds July 4, 1997, when Pathfinder landed, he adds. "I believe the American people would support the space program without people in it," Park insists.

NASA has no intention of testing that theory. It built its reputation on heroic astronauts with the right stuff. Taking joysticks from heroes and giving them to robots is like asking the Air Force to replace its top-gun pilots with automated drones. Politicians also are unlikely to back that

What Will the Space Station Do?

"It's a means to an end," says Randy Brinkley, leader of the space station program based at Johnson Space Center outside Houston. "It's a means to a new way of exploration and cooperation, a place to learn about the space environment, conduct space science, observe planet Earth, and use the microgravity environment."

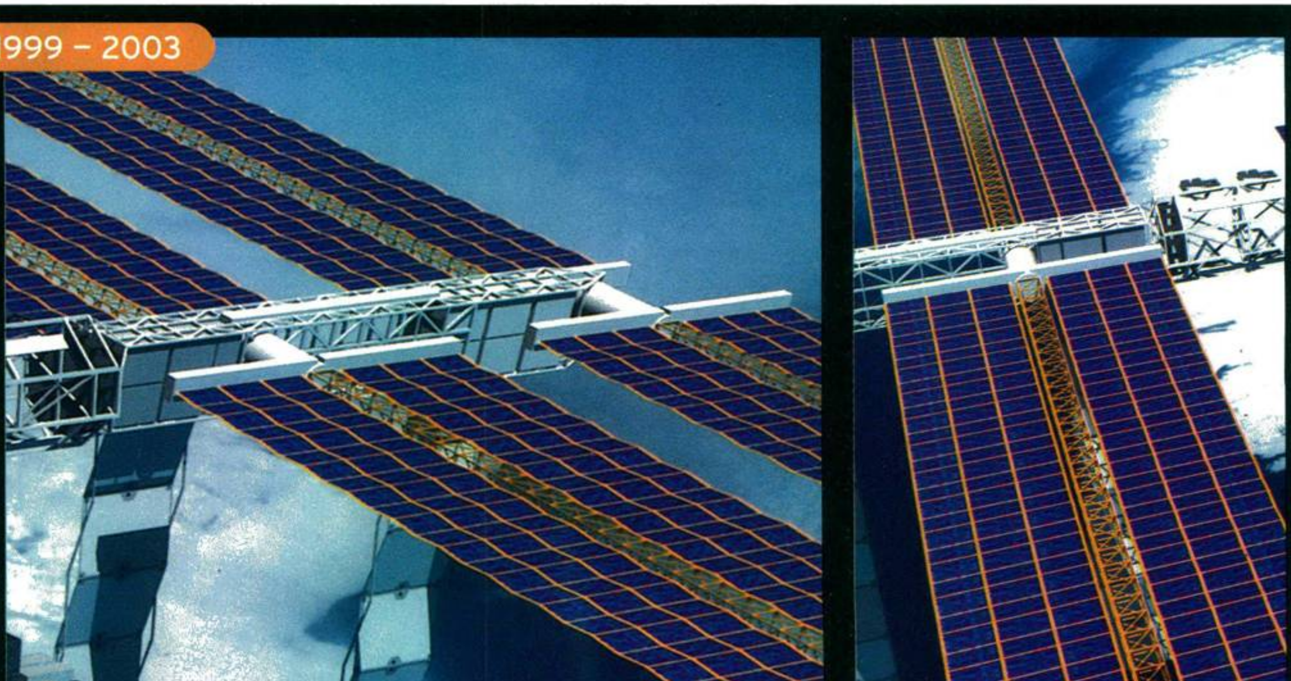
Brinkley envisions a beehive of scientific activity conducted by Americans, Russians, Germans, French, Japanese, Canadians, and a half-dozen other nationalities. They will study the effects of near-zero gravity on baby rats and grow crystals that could lead to better drugs. Outside, cameras aimed at Earth and the stars will maintain a watch.

The crew members themselves will be guinea pigs. Scientists will study the effects of radiation and microgravity on them. Such research, NASA researchers enthusiastically say, could provide data necessary to plan lengthy expeditions to Mars. They add that the information also could lead to the creation of new products, and provide clues to curing diseases like osteoporosis, diabetes, cancer, AIDS, parasitic infections, and emphysema.

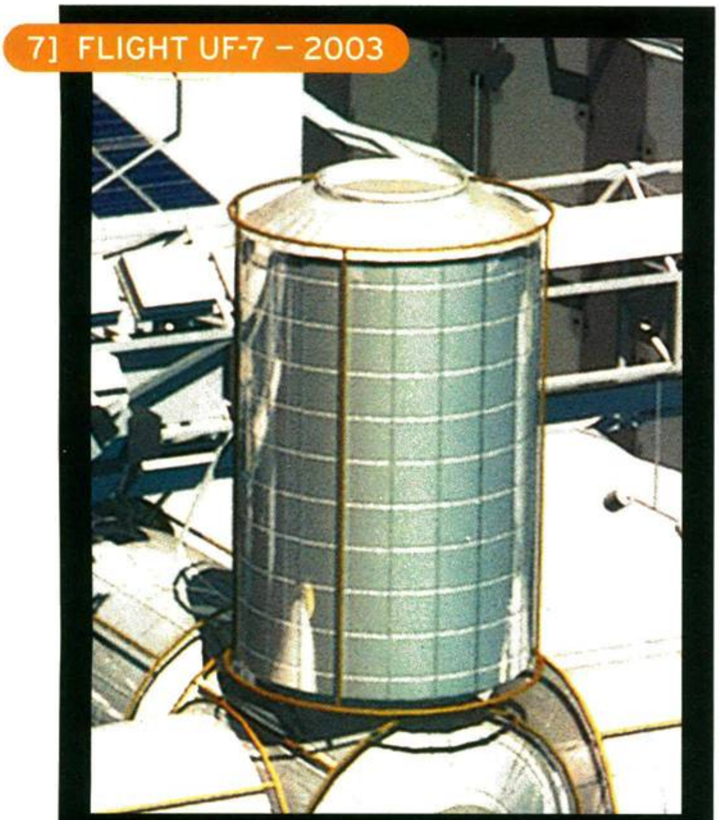
Such optimistic hopes irk many researchers. They doubt the efficacy of space-based research. Nevertheless, breathless NASA press releases predict that the medical research will help ease earthly afflictions while new materials and processes developed on the space station will "create jobs and economic opportunities worldwide." –A. L.

6] FLIGHT 1E – 2003
USA
esa

The Columbus Orbital Facility will provide additional research capability. It is the European Space Agency's primary contribution to the station.



At many points during the assembly process, astronauts will add photovoltaic panels that convert sunlight into electricity.

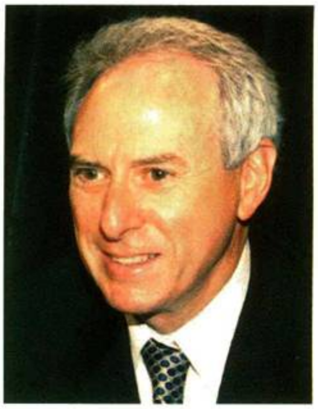


7] FLIGHT UF-7 – 2003

The Centrifuge Accommodation Module attaches to Node 2 and will complete the station's laboratory facilities. The module will control gravity for research experiments.

approach. Even Goldin, who has pushed for faster, better, and cheaper space missions, is eager to exempt the overbudget space station because he regards it as central to the agency's future.

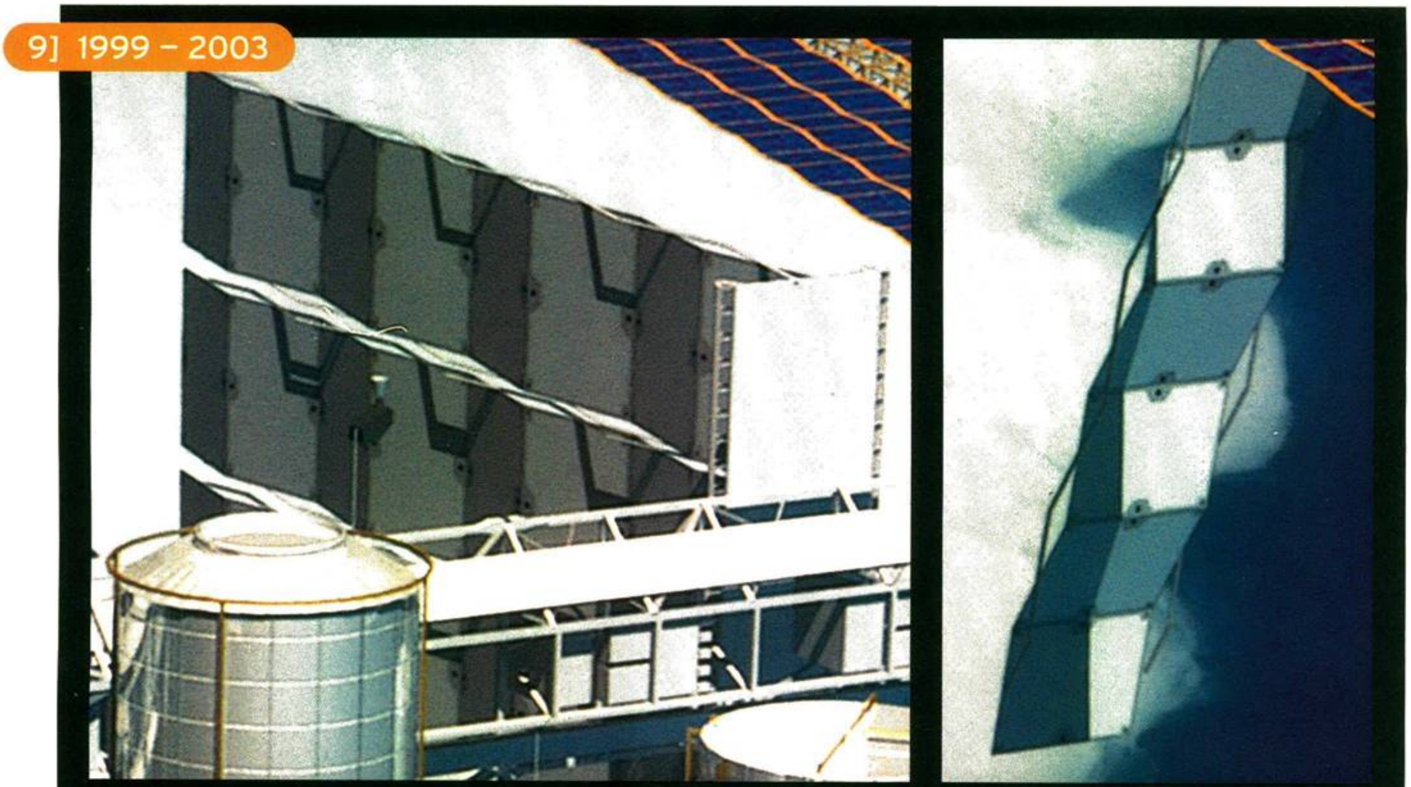
"It's the human face of the space program that has the most appeal," says Smith. Six astronauts endlessly orbiting Earth may lack the valor of a moon-walking Buzz Aldrin, but human space flight provides an element of danger, drama, and daring lacking in robotic missions. Launches involving robotic missions are sparsely attended while space shuttle launches routinely draw huge crowds.



Clinton's NASA Administrator Daniel Goldin figured out early how to catapult the space station beyond mere jobs and science: merge Russia's Mir 2 with the American project.

"It is the 20th century version of the pyramids of Giza or the cathedrals of Europe," says historian Gruen. "It's a technological program employing tens of thousands of skilled laborers, and a bold cultural statement of vision and aspiration." He adds with a laugh, "With enough time and money, you can do anything."

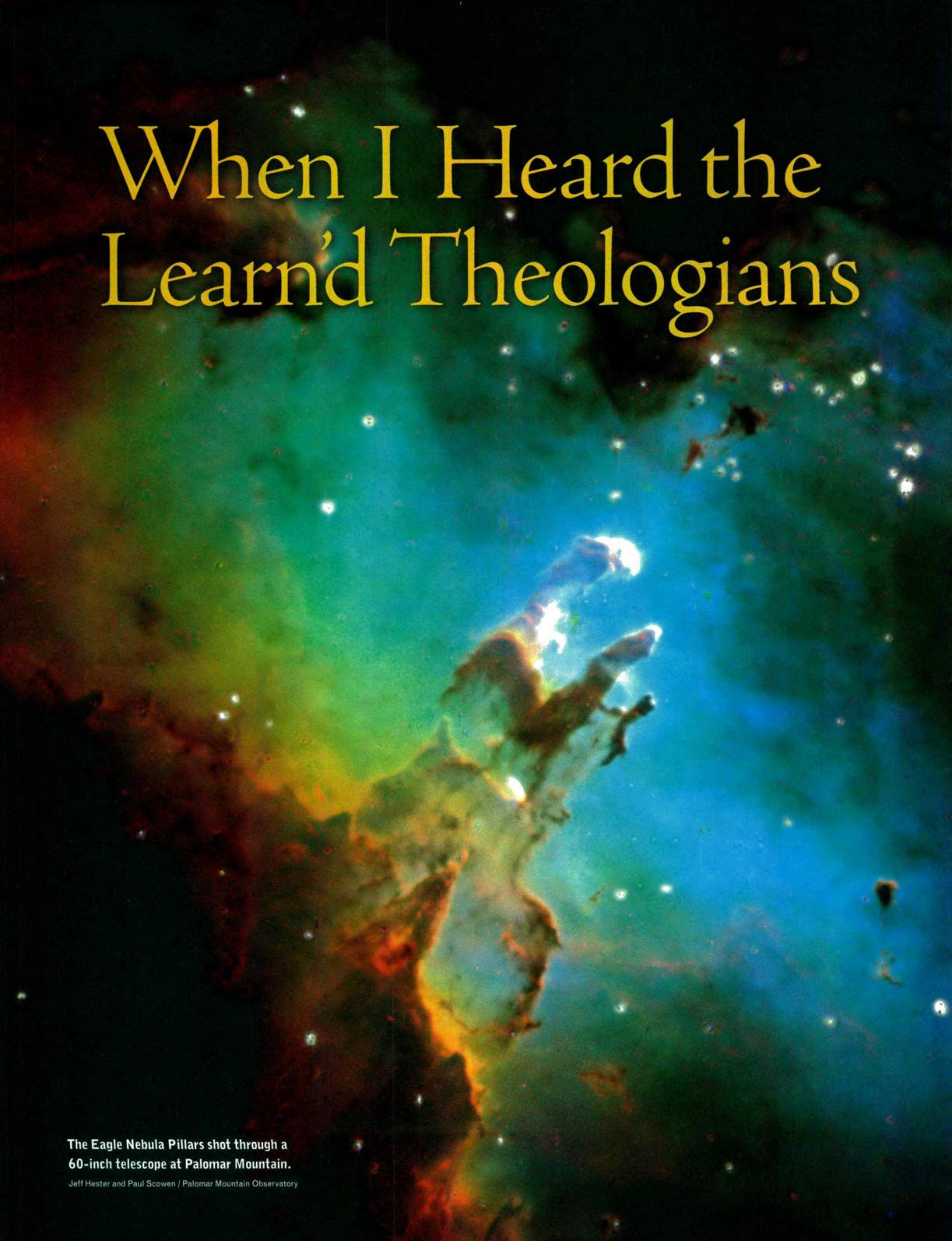
Andrew Lawler is a fellow at the Knight Science Journalism Program at the Massachusetts Institute of Technology. Lawler also writes about science policy for Science *magazine.*



9] 1999 – 2003

Heat-dissipating radiators will be added at various points in the assembly process.

When I Heard the Learn'd Theologians



The Eagle Nebula Pillars shot through a 60-inch telescope at Palomar Mountain.

Jeff Hester and Paul Scowen / Palomar Mountain Observatory

Science and religion take a careful look at rapprochement.

BY DAVID GRINSPOON

Walt Whitman's "When I Heard the Learn'd Astronomer," described his experience of a brilliant astronomer's lecture. Presented with an impressive array of charts, diagrams, and calculations, the poet soon became sick and tired, wandered off alone into "the mystical moist night-air," and "look'd up in perfect silence at the stars." Whitman's poem encapsulates a common complaint about science — that reducing the world to particles, forces, and equations can distance us from the spiritual experience of communion with nature.

Whitman wrote his poem more than 100 years ago. Today, scientists increasingly perceive their science as under attack by a wave of superstition, irrationalism, and pseudoscience. Some scientists include all religion and all spiritual belief and practice in the catchall category of dangerous anti-science. Too many people, it is said, prefer easy and comforting answers to questions posed by modern existence. Much harder to swallow is the truth — the difficult, disciplined, rational process we call science, which has revealed to us a universe in which we are disturbingly peripheral. Religion, some feel, is simply a vestigial cultural remnant from a time before we had science to explain the mysteries of existence.

But is there anything that science can learn from religion? And what about the 40 percent or so of practicing scientists who also profess religious belief? How do they reconcile these potentially conflicting approaches to the world? These were among the questions that inspired the Conference on Science and the Spiritual Quest held at Berkeley in June. The historic gathering brought together cosmologists, biologists, computer scientists, psychologists, and theologians to discuss their religious and scientific world views and ask how (and whether) the two can inform each other.

THERE IS MORE TO HEAVEN AND EARTH THAN WE DREAM OF IN OUR SCIENTIFIC PHILOSOPHY.

Excluded were the fundamentalist scientists or religionists who would regard even the existence of such a meeting as blasphemy against their orthodoxy. Rabidly anti-spiritual scientists such as biologist Richard Dawkins, who regards faith as "one of the world's great evils, comparable to the smallpox virus but harder to eradicate" were not represented. Nor were orthodox rabbis or priests, who regard the creative reinterpretation of Scripture necessary to maintain consistency with scientific revelation as invalid or dangerous.

None of the talks persuaded me that answers are to be found in the Scriptures, except those which we read into them. But the conference did provide a useful reminder that there is more to heaven and Earth than we dream of in our scientific philosophy. I was also reminded that the existence of a god who created, and cares about, this world is as obvious to some as the existence of an external material universe that can be described by simple laws is to others. We scientists like to believe that we are the masters of reality but, as the physicist and Anglican priest John Polkinghorne said at the conference, "Science is very successful because it has limited itself to a quite small but very interesting objective," namely, the description of physical reality. Remember, description is not explanation and when it comes to primary causes science explains nothing. If we find a "theory of everything" we will have a beautiful and powerful equation that relates all of the fundamental forces to each other and to the geometry of spacetime, but we still won't be able to say why it should be this way. And the universe may be, or may not be, more than physical. Many people have strong opinions about this. Nobody knows.

Among the enticing mysteries that reside on the complex boundary between science and spirituality are these:

- Why do we seem to have free will? How is this consistent with the physical universe as we understand it? Is it just a comforting illusion?
- Despite observations that seem to support the "cosmological principle" that Earth has no special place in the universe, could consciousness itself, and human consciousness in particular, hold a special place? Might consciousness be an integral, essential part of our universe rather than an accidental byproduct of certain physical processes on Earth?
- Where do moral principles come from? Is science really "value neutral?" Should it be? What responsibility does the scientific community have in general for the evil done by certain scientists working for narrow nationalistic or material motives?
- Does the objective, materialist, reductionist philosophy that has been so essential to our scientific understanding of the world also place subtle, hidden constraints on our ability to view an essential wholeness?
- Why is mathematics so astonishingly effective at describing so much about our universe?
- Why does Earth, and even the universe, seem so perfectly suited for life?
- Why should there be a universe in which people can clearly conceive of these questions, but not perceive an answer?

We scientists can pretend that these enigmas don't exist or that the success of our method has made them obsolete or irrelevant, but neither approach will gain science any respect or admirers. Indeed, if we are going to accuse others of preferring easy answers to hard scientific truths, we had better be sure that we ourselves are not avoiding any difficult questions raised by our way of understanding the world. Not that religion necessarily provides any definitive answers. For the more skeptical among us, it may never do so. But there is value in asking, rephrasing, and refining. And there is a big difference between having the courage to publicly ponder while coming up short, and refusing to even admit the validity of the questions.

In fact, some of these questions have been addressed by science, at least in part. Darwinian biology, complexity theory, and the Gaia hypothesis demonstrate that the world seems to be a perfect home for life because life and the world are inseparable, having grown up together under the combined influence of natural selection and self-organization. On another level, the anthropic cosmological principle argues that our universe seems ideally tuned for carbon-based life because, out of an ensemble of many possible

universes, we can only find ourselves in one with the right physical laws to produce such life. Recent theories of chaotic inflation posit that we may actually live in just such an ensemble of many "universes," a "multiverse" in which tiny quantum fluctuations near the beginning of time caused whole universes, of which ours is merely one, to bubble out of the void with entirely different manifestations of physical law. Does the fact that our realm of the multiverse seems so ideally suited for us imply luck, design, or the power of natural selection? I favor the last but I do not regard the question as absurd.

Many speakers prompted us to envision the ways in which the practices of religion and science are not as far apart as one might think. Scientists and skeptics often present a romanticized version of science as rejecting all authority and constantly questioning every premise. In fact, most scientific knowledge is, of necessity, handed down from authorities. I have never performed the Michelson-Morley experiment (which proved in 1887 that the propagation of light does not have a preferred direction), and neither have you. Yet we accept the result. I could never perform or witness all the experiments and calculations necessary for a full test of my faith in modern science. No one person can read and understand every article in even one issue of *Science*. My faith comes from my own limited experience with real experiment and theory, from experiences of the deep, satisfying insights and hidden beauties that science reveals, and from well supported belief in its integrity as a cultural enterprise. This conviction of integrity, in particular, allows me to accept the extrapolations I must make from my own experience to the word of the authorities. Many religious representatives argued that religion too must question, reinterpret, and search for truth, rather than unquestioningly follow an orthodoxy or dogma. Clearly there are many ways of being religious and many attitudes one can take toward one's science.

OUR RUNAWAY TECHNICAL CLEVERNESS MUST BE GUIDED BY WISDOM AND COMPASSION.

For those from either "side" open-minded enough to attend such a meeting, science and religion are less different in outlook and practice than many would assume. Both seek to understand levels of reality beyond those directly accessible to our senses. Many in attendance seemed to feel that the conference was an historic occasion that would mark the beginning of a movement toward rapprochement between these differing world views. Such dialogue is not merely interesting — it may be essential for human survival. It is obvious that humanity will not survive in our increasing numbers without a great deal of science and technology. But it should by now be obvious also that we will not survive unless that science and technology is thoughtfully applied and unless our lust for more knowledge and more powerful toys is tempered with a larger and longer view of our values, needs, and desires than simple adherence to the scientific method can provide. Our runaway technical cleverness must be guided by wisdom and compassion. That may have to come from realms beyond science or from an enlarged view of science that incorporates the spiritual.

As a step toward such reconciliation the conference was a valuable and important event. Yet I must confess that one of the most meaningful moments of the week for me came when, after a long day of impressive but weighty lectures, I wandered off alone and, upon leaving the lecture hall, heard distant drums. I followed the sound to a circle of African drummers deep in polyrhythmic reverie outside the Berkeley student union. In that circle of drums I felt the presence of spirits as old as our common human ancestors in Africa, spirits that dance with the rhythmic resonances of planetary orbits and galactic spirals. I was reminded that there are many ways of communing with the universe, many authentic modes of human spirituality that predate Western science and Western monotheism, and require no Ph.D. or Bar Mitzvah to contemplate.

Science is a uniquely human pursuit, but so is ritually shared spiritual transformation accompanied by singing and the rhythmic pounding of skins. These activities are as old and universally human as any we know. I wished I could gather up the drummers and bring them inside the lecture hall for one session in which we would all just shut up and dance. All this talk and philosophy is good fun, but it doesn't completely capture True Religion, which for me is found in many places, including when we gather together in rhythmic celebration of the cosmos or, when, in contemplation informed and deepened by reasoning and calculation, we stare up in perfect silence at the stars.

David Grinspoon is a planetary scientist at the University of Colorado, who recently authored Venus Revealed.

HIGH PRIESTS

What would Galileo say?
Priests with PhDs run the Vatican's high-tech shrine to science and explore the universe unhindered.

by Tony Ortega

There is no water in sight as we pass sand, creosote, and mesquite, but I can't help myself. I have to ask him about the baptizing-of-aliens thing.

"No, we're not about to baptize every alien. They may drink ammonia, and we don't want to poison them with baptism," quips Christopher J. Corbally, a Jesuit priest and professional astronomer driving me up the winding road to the top of Mt. Graham in southeastern Arizona. It will take us nearly an hour to reach Emerald Ridge, where the Vatican Advanced Technology Telescope (VATT) — a $4 million, world-class instrument owned by the Roman Catholic Church — awaits us. Corbally impresses me with his quick wit, but he knows he won't evade the baptism question so easily.

Smiling, he adds, "Would I baptize aliens? Yes, if they asked."

Like me, Corbally has heard the rumor that the Vatican operates a mountaintop observatory searching for space aliens to convert. He also knows its source: an Italian journalist's hyperbole in a story misquoting observatory director George Coyne. (Coyne claims to know nothing about it.)

I am questioning Corbally as we climb above the desert to the observatory: What are Catholic priests doing with a telescope? Are they looking for signs of a biblical heaven in far-off galaxies? Are the Jesuits hoping to spy the hem of God's garment in the interstellar void? Are they looking for evidence of a Genesis-inspired creation?

As these questions occur to me, I ask if he prefers to be addressed as "Doctor" or "Father."

Doug Hoeschler

OF ASTRONOMY

Mt. Graham is home to the "Pope Scope," two other observatories, and about 350 endangered Mt. Graham red squirrels. Doug Hoeschler

"WOULD I BAPTIZE ALIENS? YES, IF THEY ASKED."

— CHRISTOPHER CORBALLY

"Let's try 'Chris,' instead," answers the elfin and wryly humorous 52-year-old Brit. Above us, storm clouds shroud Mt. Graham as we ascend in a four-wheel-drive Nissan Pathfinder. We enter near-blizzard conditions at the VATT, which the people who work on the mountaintop simply call "the Pope Scope."

Corbally explains his use of the 72-inch (1.8-meter), state-of-the-art telescope: He searches for weird stars called "Lambda Boos," after Lambda Bootis, the first such star found. It's a strictly scientific undertaking by a man who has spent a lifetime pursuing science and theology. Corbally has been a Jesuit since he was 18. Ordained in 1976 at age 30, Corbally took a vow of celibacy and lives on a $16-a-day stipend. He has earned several college degrees, including a doctorate in astronomy at the University of Toronto in 1983. When he is not chasing Lambda Boos, he sometimes celebrates mass at the Newman Center on the University of Arizona campus, or at local parish churches.

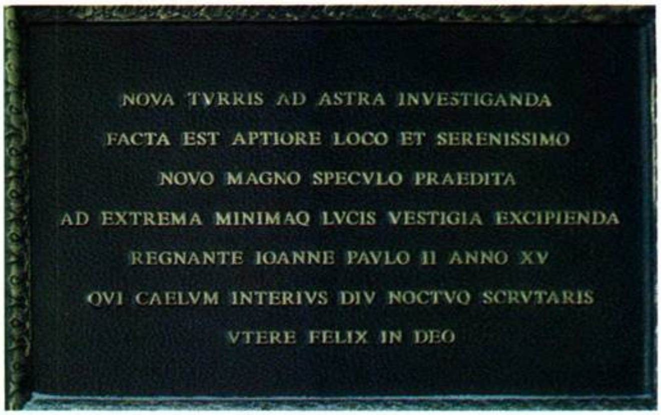
Today, however, we are celebrating science in this cathedral of high technology. It was built in a stand of Engelmann spruce and corkbark fir that currently is home to three observatories and about 350 endangered Mt. Graham red squirrels. Environmental groups were unsuccessful in using the federal Endangered Species Act to halt observatory construction.

I ask Corbally how he justifies using the mountain against the objections of Native Americans who consider it sacred. Is that an example of one religious group trampling on another?

"No," Corbally says, noting that it was only after the environmentalists' legal defeat that local tribes protested telescope development on religious grounds. Corbally says there was confusion among local tribal leaders over which peaks in the area they held sacred. However, the San Carlos Apache Community, which once included Mt. Graham within its tribal boundaries, continues to exert its right to use it for religious ceremonies.

Once we reach the observatory, we are ready for lunch. The first-floor kitchen has everything from microwave oven and gas stove to refrigerator and sink. Corbally greets Eileen Ryan, a research scientist with the Planetary Science Institute in Tucson. She and her husband Bill, an instructor at Eastern Arizona College in Thatcher, have been using the VATT during a bright-moon run. Eileen waves excitedly. In her hand is a computer tape cartridge — it looks like a fat diskette — containing data from the previous night's observations.

On the strength of a $5,000 NASA grant that pays students' expenses (the Ryans donate their time), the team measured asteroid magnitudes during a low-demand week. The Ryans intend the observations merely to familiarize students with basic telescope methods, but they have stumbled upon a gem. While observing a previously discovered three-mile-wide rock called 3800 Karayusuf, the Ryans' team found that it rotates on its axis once every 2.2 hours. The rotation is much faster than they expected. The fastest spinning asteroid that Eileen Ryan has been able to find reported in the literature is 2.25 hours. Her team may have discovered the most rapidly rotating asteroid known. (She plans to write a scientific paper on the discovery.)



NOVA TVRRIS AD ASTRA INVESTIGANDA
FACTA EST APTIORE LOCO ET SERENISSIMO
NOVO MAGNO SPECVLO PRAEDITA
AD EXTREMA MINIMAQ LVCIS VESTIGIA EXCIPIENDA
REGNANTE IOANNE PAVLO II ANNO XV
QVI CAELVM INTERIVS DIV NOCTVQ SCRVTARIS
VTERE FELIX IN DEO

Translated, this brass plaque on the observatory says "This new tower for studying the stars has been erected on this peaceful site, so fit for such studies, and it has been equipped with a new large mirror for detecting the faintest glimmers of light from distant objects during the XV year of the reign of John Paul II. May whoever searches here night and day, the far reaches of space, use it joyfully with the help of God." Doug Hoeschler

Eileen cannot wait to get back to Thatcher to download the data, but she has a disquieting thought: She fears that the small-town college's data-processing equipment won't be able to read her cartridge data correctly. Corbally puts down his ham and cheese sandwich on the kitchen's bar and tells Ryan not to worry. "Tell them that's how the Pope does it," he says.

He is happy to learn about the Ryans' success, and grateful to hear that they plan to drive down the mountain before the pelting snow makes the road impassable.

Corbally himself will risk two more hours up here showing me the Pope Scope and answering questions. He leads me to the third floor to show off the massive, squat contraption. The telescope was built in 1993. It is known officially as the Alice P. Lennon Telescope inside the Thomas J. Bannon Astrophysics facility.

The telescope's mirror looks impossibly concave — it is so steeply curved that the parabolic mirror focuses light only 1.8 meters from its surface, producing a focal ratio of 1. (The majority of new, large telescopes have longer focal ratios of f/2 to f/4.) Such a sharply curved f/1 mirror requires an incredibly precise surface polish, because the shorter the focal ratio, the greater is the requirement for an exact parabolic curvature, especially on the mirror's outer edge where the curvature is the greatest. The University of Arizona's Mirror Laboratory, which was started by astrophysicist J. Roger Angel, cast the VATT mirror in a rotating furnace and later polished the parabolically curved glass.

"An Angel mirror in the Pope Scope? Sure," Corbally says as he points to other features.

Dwarfed by the telescope, Corbally talks about his search for stars that resemble Lambda Bootis, a 4th-magnitude denizen of the Milky Way Galaxy. Lambda Boos seem bizarre. They don't look like other stars that populate the galaxy's disk; they lack many of the elements heavier than helium — called "metals" despite their gaseous form — contained by most stars in our galaxy. Massive stars mint these heavy elements when they die in spectacular explosions called supernovae. The explosions scatter the metals into clouds of interstellar gas and they are recycled later into new stars. Somehow, Lambda Boos don't contain these heavier metals: They are made of only the simplest elements and therefore resemble ancient stars found in the galaxy's halo and globular clusters.

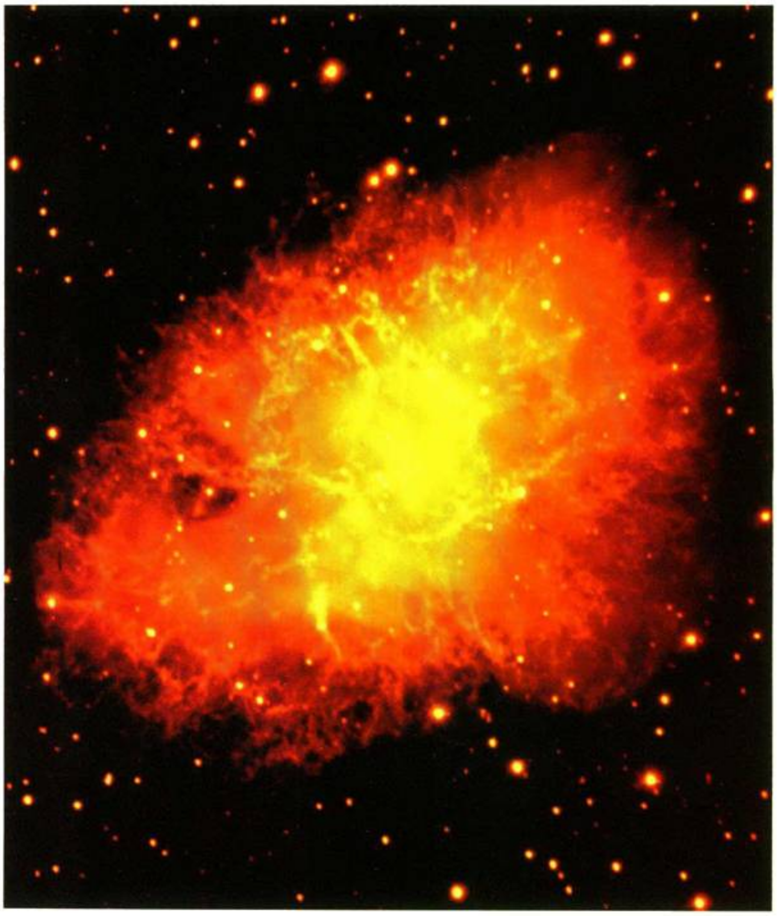
Corbally and others have identified about 45 of these metal-poor Lambda Boos, including young stars in clusters surrounded, mysteriously, by stars rich in metals. It's as if the stellar factories churning out Maseratis occasionally belch out a Model T. Astronomers aren't sure why it happens.

The mystery fascinates Corbally. He goes about solving it the same way other scientists do — by dissecting the complicated patterns of light, called spectra, coming from the stars. A star's spectrum reveals its chemical makeup, including its metal content. A solution to the Lambda Boo puzzle will help scientists understand stellar evolution, Corbally says, which could in turn shed light on the evolution of the universe.

Corbally's six Vatican colleagues use the VATT to investigate other planetary, stellar, and cosmological riddles. University of Arizona astronomers and other users of the VATT — such as the Ryans — may have no other connection to the Catholic Church. In fact, except for the priest's collar Corbally has donned obligingly for a photographer, a brass plaque from the Vatican, and a Bible on a bookshelf, there is no other clue that this high-tech shrine of science is operated by men of God. But the scientific appearance of the place doesn't keep me from wondering: What are priests doing practicing astronomy?

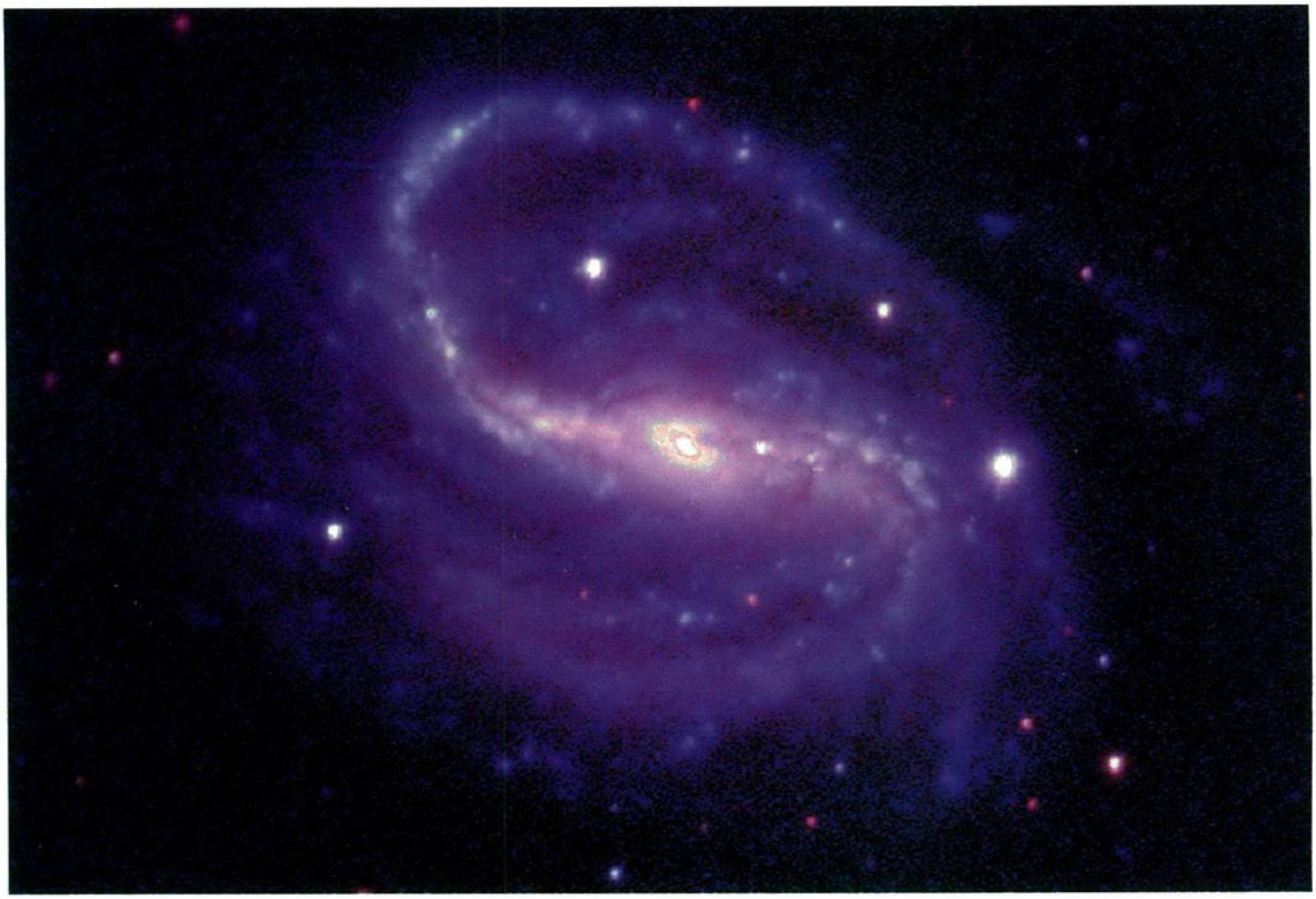
Conflict often defines the interaction between science and religion. However, outspoken religious astronomers and the authors of a spate of recent popular books suggest that science and religion have become compatible ways of understanding the universe.

"Theology is not going to tell science how to do science. Science is not going to tell theology how to do theology," says Corbally. "But one can help the other ask deeper questions and find deeper answers." He notes that such a harmony has not always existed: "It took the Church a while to assimilate that, especially since early this century."



This image of the Crab Nebula was made with a CCD camera at the Vatican Observatory in 1995. The nebula is the remnant of a supernova explosion noted in 1054 A.D.

VATT/Columbia University



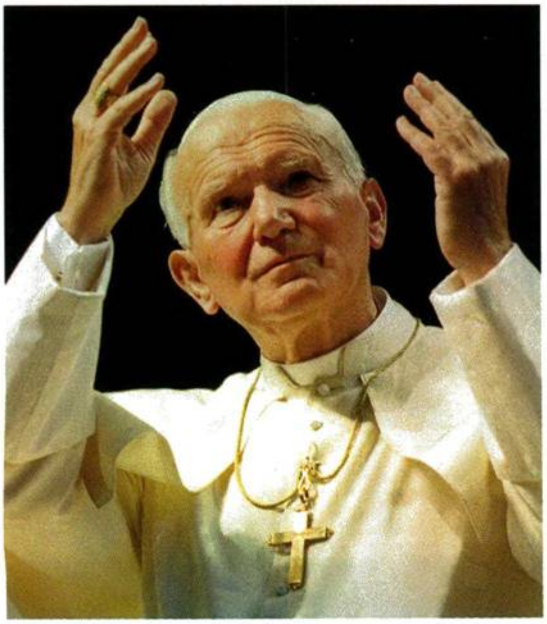
This real-color image of spiral galaxy UGC 12343 was presented to Pope John Paul II at a meeting of the Pontifical Academy of Sciences on the formation of galaxies. VATT

In 1633 the Catholic Church put the aging Galileo under house arrest during the final eight years of his life for advocating a Copernican, or heliocentric (sun-centered) view, which was in opposition to the church's geocentric (Earth-centered) teachings. Until 1992, the church refused to admit its error. Its condemnation of Galileo crystallized a schism that would stand for centuries: the mathematically rational, empirically based world of science versus religion's dogmatic, faith-based belief systems.

Yet if Galileo came to represent the split between science and religion, many writers have noted that his case actually was not so clear-cut. Catholic scholars such as Princeton University's Stanley L. Jaki bristle at the notion that Galileo's plight branded the church anti-science. Despite having a friend in Pope Urban VIII who professed an interest in astronomy, Galileo seemed to take obvious glee in provoking the Catholic Church, something his contemporary, astronomer Johannes Kepler, found foolish and blatantly counterproductive. Aristotelian university professors, threatened by Galileo's popularity, also united against him and pointed out to church leaders that Galileo's heliocentric view contradicted the Scriptures.

Prominent astronomers, Jaki points out, have not only included lay Catholics but priests as well. For example, historians credit astronomer Georges Lemaître, a Belgian Jesuit priest, with formulating the big bang theory in 1931.

The Vatican has had an interest in astronomy at least since the 16th century, when Pope Gregory XIII established the Gregorian calendar still in use today. More than any other priests, it has been the Jesuits, a missionary and educational order



In 1992 John Paul II said the Church made a mistake and he apologized for the arrest of Galileo. Catholic News Service founded by Ignatius Loyola in 1534, who have pursued the sciences on behalf of the church. The Vatican Observatory itself grew out of a Jesuit college in Rome.

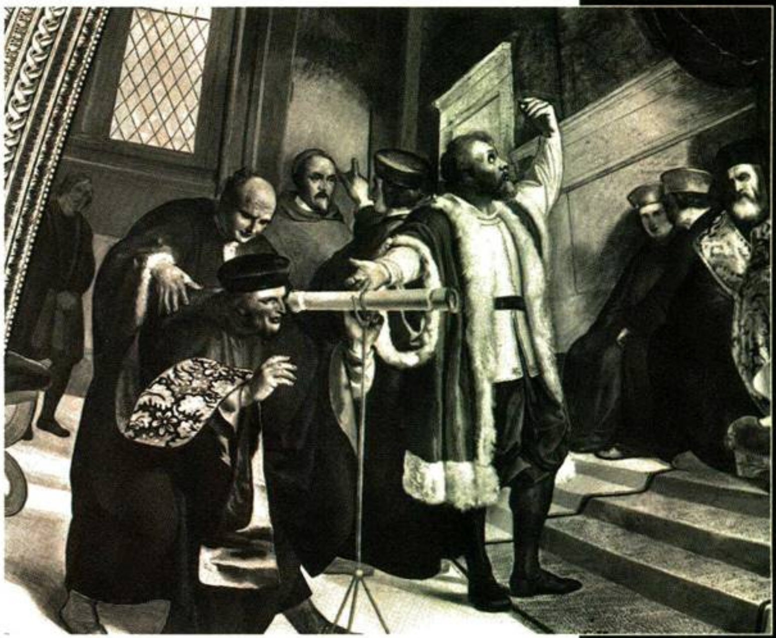
Founded in 1891, the observatory's early work included contributing to the notorious Carte du Ciel project, an international attempt to map the entire sky at an incredibly comprehensive level. The project was recently finished. It was a sort of scientific grunt work that characterized the early decades of Vatican Observatory research, Corbally says. (He adds that computers — meaning nuns — did much of the Carte du Ciel work.)

The observatory has a purpose for the Vatican in addition to its astronomical mission: public relations. Corbally admits that the Church was motivated to study astronomy at least in part to counteract its reputation for ignorance in its treatment of Galileo. The Church does penance up here. It also boasts that it sponsors the most advanced scholarship of, ironically enough, Galileo's life and work.

In the 1950s, several new astronomers brought modern techniques and theories to the observatory and put it on a path toward cutting-edge science. By then, the Church moved the observatory to Castel Gandolfo, an estate outside Rome, to get away from Rome's increasing light pollution. The observatory continues to use Castel Gandolfo as a museum and for teaching, but has moved its research staff here to the dark desert skies of Arizona. VATT director George Coyne studies the flow of matter between cataclysmic variable stars. Richard Boyle investigates the metallicity of stars for clues to the evolution of the Milky Way Galaxy. Martin McCarthy studies red-hued carbon stars. William Stoeger contemplates the gravity of black holes, and Corbally chases Lambda Boos.

Brother Guy Consolmagno, co-author with Dan M. Davis of *Turn Left at Orion*, traveled to Antarctica recently to pick up meteorites. Unlike his VATT colleagues, who entered the religious order before they became scientists, Consolmagno became a cleric relatively late in his life. He followed graduate work with postdoctoral fellowships in planetary science at Harvard and MIT. He had been a professional astronomer for 15 years before he chose to become a Jesuit. Consolmagno says his decision to take vows of poverty and chastity at the age of 35 gave more meaning to his work. "Now, I do science for the glory of God, not the glory of Guy. It's a lot more fun that way," he says.

"Why do I believe in God? It's not because of the beauty or symmetry or design of the universe that I see in my science, even though all of those things can lead me to appreciate the God I already believe in ... It's not because some particular scientific theory is true or false, but because truth and falseness themselves are important. And because, the last time I asked God if He existed, His reply was, 'Last time I looked, I did.'"



In 1609, Galileo presents a 9-power telescope to the Venetian senate, which endowed the astronomer with a lifetime professorship and a large salary. Corbis-Bettmann

Their scientific views, however, require both Corbally and Consolmagno to read the Bible as more metaphor and less literal truth. "People who make the Bible into a science book do it no favor," says Consolmagno. "The Bible is a book about God, not about nature. To find out something is a myth is not to say it is untrue. A myth is something that enshrines the truth. So one has stories in the Bible enshrining the truth."

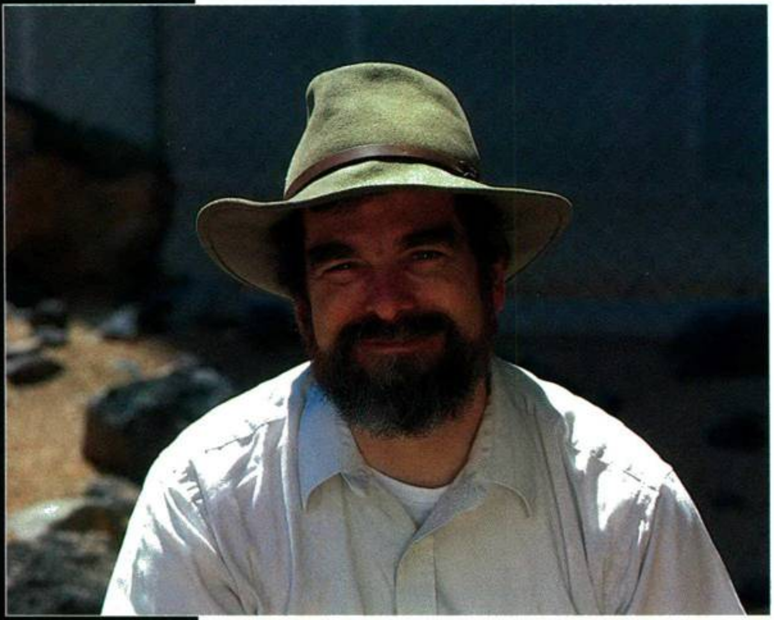
Corbally doesn't find fundamentalists among the scientists he meets. At meetings he doesn't encounter Protestant literalists and other religious groups that resist evolutionary theories of biology and cosmology. However, the Catholic Church recently has officially embraced biological evolution and other mainstream scientific theories. Pope John Paul II made that explicit in 1996, four years after his apology for the Catholic Church's treatment of Galileo, with his widely reported proclamation *New Knowledge*. In it, John Paul said his Pontifical Academy of Sciences "has led us to realize that the theory of evolution is no longer a mere hypothesis."

The Pope's affinity with science, meanwhile, has been matched by a growing interest in religion from scientists. The continued acceptance of the big bang theory and the strangeness of quantum physics apparently prompt the coziness.

Princeton's Jaki and others argue that a finite cosmic beginning implied by the Big Bang suggests the truth of the Judeo-Christian version of creation. Of all of the world's major religions, Jaki writes, only this tradition predicts a creation of the cosmos from nothingness rather than cyclical, endless existence.

Other writers have made similar arguments about modern physics "proving" the felicity of

ARISTOTELIAN PROFESSORS, THREATENED BY GALILEO'S POPULARITY, POINTED OUT THAT HIS VIEW CONTRADICTED SCRIPTURES.



Brother Guy Consolmagno, co-author of *Turn Left at Orion*, says religions should resist the urge to validate their beliefs with scientific results. Lori Stiles

"NOW, I DO SCIENCE FOR THE GLORY OF GOD, NOT THE GLORY OF GUY. IT'S A LOT MORE FUN THAT WAY."

— GUY CONSOLMAGNO

religious doctrines: Relativistic time dilation — God moving at nearly the speed of light — explains why creation literally took six days (*Genesis and the Big Bang* by Gerald L. Schroeder); the strange behavior of subatomic particles mirrors Taoist, Hindu, and Buddhist mysticism (*The Tao of Physics* by Fritjof Capra); cosmology's inability to describe the nature of the universe in the first 10^{-43} second implies not only God's role in starting the universe, but also suggests that belief in Jesus Christ as a personal savior is a good idea (*Show Me God* by Fred Heeren).

But Corbally and Consolmagno argue that those books make the same error as that made by the Catholic Church when it clashed with Galileo. They argue that religions must resist the rush to validate their beliefs with selected scientific findings. For Jesuit scientists, theology describes a realm that science cannot approach. No telescope or supercollider, no matter how large, could ever prove or disprove the existence of God, they say.

"No one was ever converted by a syllogism," says Consolmagno. "While the modern advances in physics have given scientists a well-deserved dose of humility, I really don't see that they have fundamentally made believers out of atheists, or vice versa. Placing God at 'the beginning' or in places that science cannot explain — yet — is the fallacy of the 'God of the gaps.' Not only do you have the problem of squeezing out God as the gaps get filled in, your concept of God also is held hostage to future advances in science."

Science, after all, is based on the notion that new empirical evidence could force scholars to make radical changes to the most entrenched theories. For this reason, Corbally doesn't share Jaki's assertion that the Big Bang proves the Judeo-Christian creation story. Corbally says theories that link scientific discoveries with religious belief are amusing, not revelatory. "I wouldn't want to pin my faith on them," he says.

The Catholic Church came to the same conclusion after nearly seizing on the Big Bang as evidence of biblical truth. In the early 1950s, Pope Pius XII discussed with the scientists in his Pontifical Academy his feelings that an expanding universe might prove the existence of God. Pius XII made Academy member Lemaître, the originator of the big bang theory, very nervous.

At that time steady-state advocates were attacking Lemaître and his big bang theory. The discovery of the cosmic background radiation — observational evidence supporting the Big Bang — was still years away. Lemaître wanted to stop the Pope from risking a terrible misstep. The Pope, after all, is infallible, and Lemaître knew his theory was not. A proclamation by Pius XII that the Big Bang proved the existence of God — possibly to be followed by scientific evidence disproving the theory — could be a disaster for the Church as embarrassing as its arrest of Galileo. Catholic scholar Jozef Tuzek wrote that Lemaître managed to persuade the Pope to make no statements about the theory.

Today, the Church claims to study science for its own sake, not in the hopes of finding physical proof of biblical veracity. As a result, Consolmagno and Corbally are freer than Galileo to let their investigations take them where they will. They are under no Vatican directive to prove or disprove any theory. Believing that all of nature is sacred, the priests of Mt. Graham simply seek to learn how God's universe works.

For other astronomers, science is enough. However, Consolmagno says even skeptics appreciate his standing within the Church. At conferences, colleagues pull him aside as if they want to give a confession. Some astronomers talk about their personal lives and regard him as colleague and confidant. Consolmagno gladly provides the service.

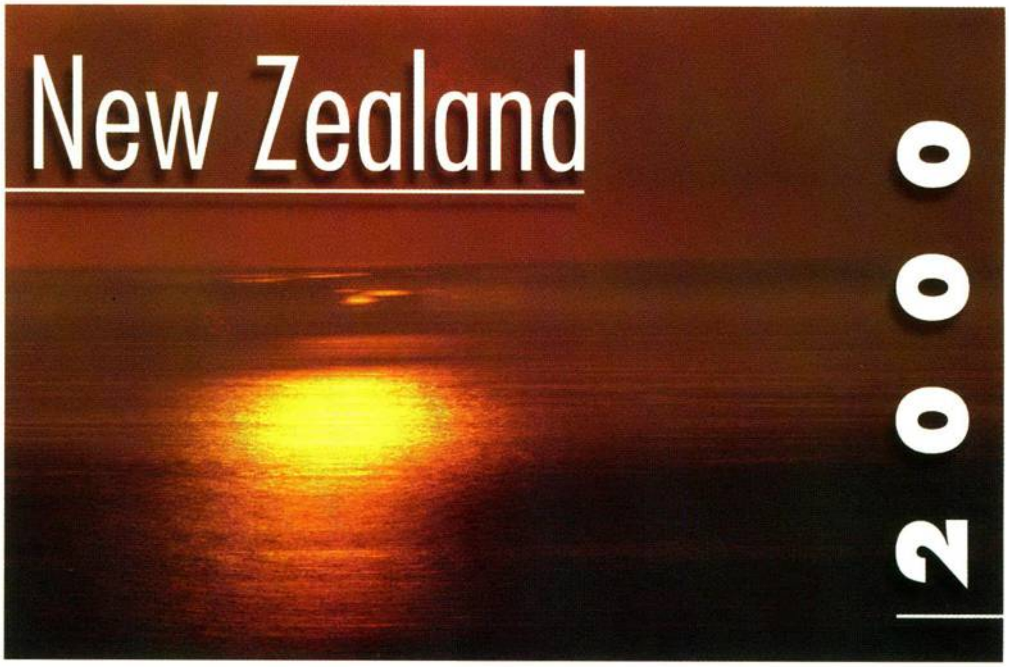
Their lay colleagues now are accustomed to working with priest-astronomers, say Corbally and Consolmagno. Friends tend not to ask bizarre questions about baptizing aliens. But Corbally has heard astronomers muse about the advantages of working for a science-friendly pope.

"Instant tenure and unlimited resources?" Corbally asks rhetorically, acknowledging that his secular colleagues do not have those luxuries. How many would work for Corbally's $16-a-day stipend and take a vow of celibacy? I leave that question unasked as we drive through the snowstorm. My nosiness only takes me so far.

Tony Ortega is a freelance writer in Phoenix, Arizona. His last article for Astronomy *was a profile of Robert Burnham, Jr. He can be reached at tortega@newtimes.com.*

Astronomy Magazine presents

The Millennium Tour



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Devouring *the* Future

By consuming everything that falls into them, Stephen Hawking's black holes destroy our ability to make predictions.

by Kitty Ferguson

ISAAC ASIMOV ONCE WROTE THAT "OF ALL the stereotypes that have plagued men and women of science, surely one above all has wrought harm. Scientists can be pictured as 'evil,' 'mad,' 'cold,' 'self-centered,' 'absent-minded,' even 'square' and yet survive easily. Unfortunately, they are usually pictured as 'right' and that can distort the picture of science past redemption."

If our picture of a scientist is "someone who is right," Stephen Hawking shatters this stereotype. Not only does he flatly refuse to discuss whether his theories represent reality, but on his search for "the truth behind everything" — something he says he's wanted to know ever since he was a child growing up in Highgate and St. Albans, England — he dares to make startling about-faces, or at least what seem so if we don't comprehend the subtle connections between his discoveries.

It was Hawking's paradoxical view of reality that he and I discussed on a spring afternoon in 1996, when I visited him for tea in the Department of Applied Maths and Theoretical Physics at Cambridge University. His latest popular book, *Black Holes and Baby Universes*, had annoyed some critics, because he had written that a theory in physics is just a mathematical model and that it makes no sense to ask whether it corresponds to reality. You can only ask whether its predictions agree with observation. Regardless of how curious the rest of us may be, Hawking finds it meaningless to discuss questions such as whether wormholes really do exist.

We had our tea in the department common room amid a noisy assembly of students and physicists. Hawking holds the title of Lucasian Professor of Mathematics at Cambridge (the same chair once held by Isaac Newton) and is Companion of Honor to the Queen. But such distinctions don't set anyone apart at the daily four-o'clock tea, where the dress is casual to the point of scruffy, the language is a mixture of English and mathematics, and equations are scribbled on the surfaces of the low tables. "When we want to save something, we xerox the table," quips Hawking. Conversations range across the span and history of the universe. When it is Hawking who is conversing, the discussion moves slowly, with long pauses while he composes his sentences using a computer speech program.

Prisoner in His Own Body

In the winter of 1963, Hawking was a first-year graduate student at Cambridge. He had received his undergraduate degree from Oxford the spring before. Soon after his 21st birthday, he was diagnosed with amyotrophic lateral sclerosis (better known in the United States as Lou Gehrig's disease), an incurable affliction that causes gradual disintegration of the nerve cells regulating voluntary muscle activity. As nerve cells disintegrate, the muscles they control atrophy. Eventually this happens to every muscle of the body. The brain, meanwhile, remains completely lucid. Hawking's doctors initially told him he had two to three years to live. That was 35 years ago. In the course of those years, the disease has gradually deprived Hawking of the ability to walk, talk, feed himself, or raise his head if it tips forward. Since the mid-1980s, he has required round-the-clock nursing. But none of this has robbed Hawking of his ebullient spirit or prevented him from leading an active and productive life.

Hawking hears and sees as well as anyone. But when he communicates his thoughts to someone else, his computer is his only link. As words scroll by on the screen, he chooses

Photo: Bantam Books; Illustration: James Yang

E=MC²
(A+B)²=(B+A) πr²
5+4+3+
particle theory
Quantum
Information
is no
nd nobo
will be n
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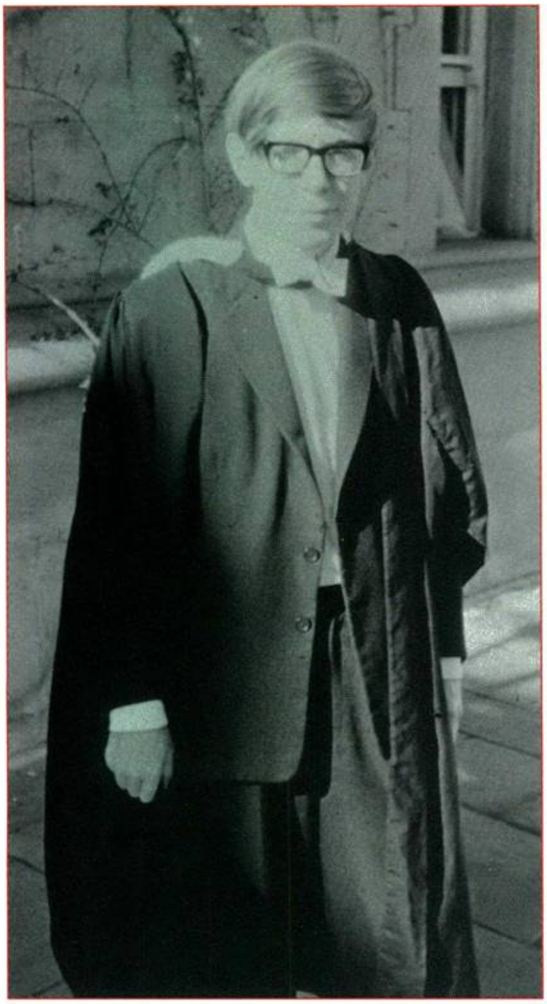
lionair
e ar
sp
SUGAR

He has mastered the art of saying precisely what he means in the fewest possible words.



Stephen Hawking graduated from Oxford University at age 20 in 1962, a full year before the onset of his illness.

Stephen Hawking

those he wants, one by one, with a slight pressure of his hand on a computer mouselike device — almost the only motion he is still capable of making. Completed sentences take shape at the bottom of the screen and, finally, a synthetic voice (in an American accent, to his chagrin) enunciates what he has composed. The process requires patience from Hawking and those around him.

Because of Hawking's lack of body language and vocal nuance, ambiguities sometimes hamper understanding. The synthesized voice conveys only one mood: infinite, thoughtful patience, which lends an oracular air to his statements and means that Hawking's humor comes across as dry wit whether he intends it that way or not. In spite of the difficulties, colleagues, students, and friends find what Hawking says worth waiting for. Though he doesn't resort to shortcuts such as leaving out "the" and "a," he has mastered the art of saying precisely what he means in the fewest possible words.

Our conversation about reality had to be cut short because Hawking was scheduled to give a public lecture. The tickets, distributed through the university, had all been snatched up weeks before. His graduate and post-graduate students, however, were to be admitted without tickets. Someone suggested I might come along with them, and Hawking agreed. I tried to do my best to look as young and disheveled as they.

The lecture was a media event with sound trucks outside and cables snaking in, stage and audience spotlighted for cameras. The hall was large and modern, an amphitheater seating about 500 people on long, curved, desklike benches, with more crowded into the balconies above. There was a sudden hush as the motorized wheelchair rolled slowly onto the platform. Hawking had pre-programmed the text into his computer so that the lecture could progress without any lengthy pauses. An assistant worked a slide projector. Even when the lecture and slides skated off into formulas and diagrams that few could understand, Hawking commanded the rapt attention of his audience.

Later, with the printed lecture notes before me, it was easier to decipher what he'd talked about. It had to do with a major thrust of his current work — information lost in black holes and what that loss implies for our ability to understand the universe and predict what happens in it. (The lecture appears in his book *The Nature of Space and Time*, co-authored by Roger Penrose of Oxford.) Once again, Hawking was pulling the rug out from under his own previous conclusions.

Master of Contradictions

He has a history of such rug-pulling. In his doctoral dissertation in the late 1960s he found that if general relativity holds true, the universe *must* have begun as a singularity, with everything compressed to a point of infinite density. In the early '80s, however, he and American physicist Jim Hartle took another look at the origin of the universe and developed their "no boundary model" in which, in "imaginary time" (a mathematical device that allows the time dimension to become a fourth spatial dimension, so that chronological time no longer exists) the universe has no beginning at all.

Now he was altering course again. In 1990 he'd given a lecture entitled "Is Everything Determined?", concluding that everything that happens, has happened, or ever will happen, has been determined either by God or a Theory of Everything. In the lecture I attended, part of a debate between Hawking and Penrose, Hawking announced that the universe is not so deterministic after all.

Hawking is endlessly fascinated by the history of science, and he traces the present discussion to Pierre Simon de Laplace in the early 19th century. He teased his audience by first quoting Laplace in French and telling them that since they were a Cambridge audience he would not insult their intelligence by offering a translation. Laplace (paraphrased, nevertheless, in English on the screen) proposed that if at any one time we knew the positions and velocities of all the particles in the universe, and also the laws of the universe, we could calculate the positions and velocities of all particles at any other time in the past or future. Scientific determinism to the hilt! Though no one denied the stupefying practical difficulties of such knowledge and calculation, scientific determinism remained dogma throughout the 19th and early 20th centuries.

Enter quantum mechanics — the science of the very small: molecules, atoms, and elementary particles. It took 26 years (from 1900 to 1926) for anyone to realize how much our growing knowledge of the quantum level of the universe might undermine the dogma of scientific determinism. German physicist Werner Heisenberg pointed out the difficulty in his famous "uncertainty principle": The more accurately you measure the position of a particle, the less accurately you can measure how it's moving, and vice versa. There is no possibility of precisely pinning down a particle's position and momentum simultaneously. So much for Laplace's version of determinism, which required knowing the positions and momenta of all particles at one instant of time.

Albert Einstein was offended by the idea of such randomness in nature. "God does not play dice," he insisted, to which the great Danish physicist Niels Bohr retorted, "Albert, don't tell God what He can do!"

Quantum theory is highly successful and serves us magnificently on both the practical and the theoretical levels. The same is true of Einstein's general theory of relativity, which deals with the way space and time are curved or warped by matter and energy. Nevertheless, there are problems in trying to make these two theories work together. Hawking once commented that if both theories are correct, the universe either should have curled up into a small ball or expanded in such a way that galaxies couldn't form. A hasty glance around tells us neither has happened.

The problem of resolving this inconsistency and combining these two theories — quantum theory and general relativity — has been of major interest to Hawking for more than 20 years and continues to preoccupy him. The goal: to produce a theory of "quantum gravity."

Hawking described part of this scientific quest in the bestseller *A Brief History of Time*. I was thrown for a loop when he wrote in pages 100 to 102 that a black hole's event horizon (the outer border) can never grow smaller — and then on page 107 he declared that it *can* grow smaller.

E=MC²
(A+B)(B+A) πr²(z+

Hawking has yet to win the Nobel Prize, but he is seen here in 1988 receiving the Wolf Foundation prize, Israel's equivalent to the Nobel Prize. Israeli President Chaim Herzog (right) and Education Minister Yitzhak Navon (center) congratulate Hawking. Reuters/Corbis-Bettmann

Indeed, the black hole can lose mass, shrink, and eventually evaporate entirely. But how could that be so when he'd defined "black hole" in the glossary as "a region of space-time from which nothing, not even light, can escape"? How could it lose anything? Hawking was troubled by his own discovery. He struggled with it before announcing it to a resistant scientific community.

As I read *Brief History* in the late 1980s, it seemed to me that Hawking contradicted himself all over the place. It took the best efforts of one of his post-graduate assistants to show me how in "classical" theory a black hole can never lose mass or shrink, but when you bring in quantum theory, all sorts of things can happen. Hawking had made the first successful attempt to have the two theories — general relativity and quantum mechanics — work together.

He had taken note of the scientific tenet that there's no such thing as empty space. Instead there are "quantum fluctuations" at all times and everywhere, and it's easiest to think of them as the appearance and disappearance of pairs of particles. Two members of a pair separate and then rejoin after an unimaginably small fraction of a second, annihilating each other. Hawking asks us to think about two of these particles exchanging energy perilously near a black hole's event horizon, one ending up with negative energy, the other with positive energy. If the negative energy particle falls below the event horizon, that allows the positive energy particle to speed away from the black hole, never to rejoin its partner. As the negative energy particle falls in, it subtracts energy from the black hole.

Because Einstein's equation $E = mc^2$ showed us that energy and mass are really two forms of the same thing, a black hole losing energy is a black hole losing mass, and that means it's getting smaller. This sleight of hand goes on at the border of every black hole in the universe, but the effect is particularly noticeable around tiny ones the size of an atomic nucleus and smaller. Black holes eventually evaporate completely. And *that*, says Hawking, turns out to have ramifications for how predictable the universe actually is.

Destroyer of Determinism

Although quantum mechanics, as we've seen, leads to uncertainty if you try to predict both the position and motion of a particle, there is a remnant of predictability left because it is possible to predict with certainty a *combination* of position and momentum. Or so scientists have been thinking. Hawking has his doubts.

Despite his affliction, Hawking leads an active life. He and his wife recently visited President Clinton. The White House

When particles or unfortunate astronauts tumble into black holes, not only do they never come out again, but the information they carry — the sort necessary for Laplace-style prediction or even something less ambitious — is lost, at least from our region of the universe. Now if black holes go on existing forever, then so does the "lost" information. It's inaccessible, but it's still there. But what if Hawking is right about black holes eventually evaporating? The "escaping" particle doesn't come from inside the black hole, but from just outside, and it carries with it no news whatsoever about whether the black hole is full of astronauts or unmatched socks. Eventually, as the radiation continues, there is no black hole left. Where did the information go? Is every black hole in the universe thumbing its nose at Laplace and even less optimistic semi-determinists?

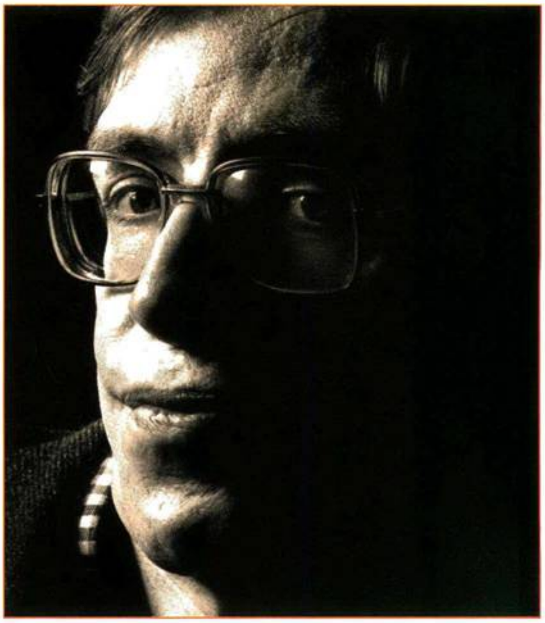
The bottom line, says Hawking, is that information will be truly lost when black holes form and then evaporate, and this means we can predict even less than we thought on the basis of quantum theory. Whatever we can measure about the escaping particle, we can measure nothing about the particle that fell in, and a definite prediction about either one of them would have to involve both members of the pair. "Not only does God definitely play dice," quips Hawking, "but He sometimes confuses us by throwing them where they cannot be seen."

Many scientists assume the Einstein role in a new version of the old debate: Surely information is not really lost down black holes. The problem is finding a mechanism to return the information. Hawking thinks there is none.

Does it matter? So what if determinism breaks down around black holes? You and I and Stephen Hawking don't live near one. But Hawking says that there's another implication of Heisenberg's uncertainty principle: Every region of space should be full of tiny black holes that appear and disappear as rapidly as the particle pairs we've been talking about. Don't these little guys gobble up particles and information too? Surely they must, thinks Hawking, although they are too small — a hundred trillion times smaller than an atomic nucleus — to eat much. Nibble perhaps, but not gobble. That's why, says Hawking, the laws of science appear deterministic for most everyday intents and purposes.

But in extreme circumstances, in the early universe or in high energy particle collisions, there could be significant loss of information, resulting in unpredictability when it comes to our knowing how the universe has evolved and where it will go from here. "The future of the universe is not completely determined by the laws of science and its present state as Laplace thought," Hawking ended his lecture. "God still has a few tricks up His sleeve." The last slide was a drawing of an elderly, bearded, smiling figure slipping playing cards into the sleeve of his robe.

And the future for Stephen Hawking? Thirty-five years after receiving a death sentence, here he is, hard at work in his office for many hours each day at one of the world's premier universities; surrounded at teatime by students, colleagues, and visitors who pay close attention to his carefully chosen words and enjoy his wry humor; authoring books and articles; hosting popular television specials; traveling the world to attend meetings and conferences and give public lectures to sold-out audiences. His academic colleagues think of him as treading the frontiers of their field, sometimes a little too daringly. The public has made him a celebrity on a par with rock stars.


Stephen Hawking ponders the question of whether the disappearance of information into black holes signals the death knell of determinism. Francis Giacobetti

"Not only does God definitely play dice, but He sometimes confuses us by throwing them where they cannot be seen."

Hawking is 56 years old now, has two grown children and a younger son attending a university, and has recently married for the second time. He proclaims himself "in no hurry to die," and his present doctors say his condition has stabilized. No wheelchair, nurses, or synthetic speech can disguise the fact that this is an exuberant man, intensely alive intellectually, "having it all together" more than most of the rest of us, and extraordinarily well-pleased with life. ■

Kitty Ferguson is author of the bestseller Stephen Hawking: Quest for a Theory of Everything. *She has also written* Prisons of Light: Black Holes *and* Fire in the Equations: Science, Religion, and the Search for God. *Her new book,* Measuring the Universe, *will appear in the spring.*

Astronomy is delighted and honored that Professor Stephen Hawking answered a reader question for this month's Ask Astro. To see his answer to a question about colliding black holes, turn to page 113.

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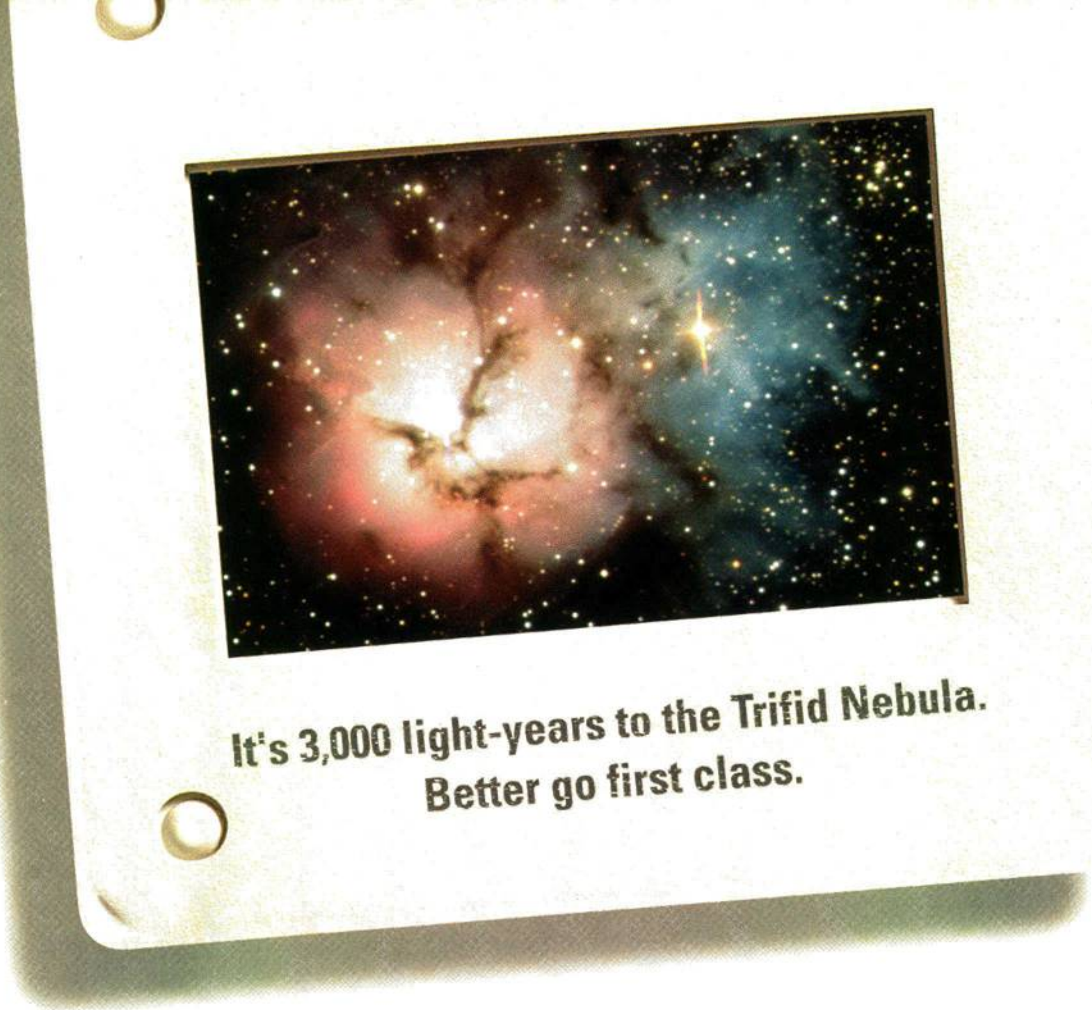

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THE SKY SHOW

Lunar occultations, Geminid meteors, and a conjunction of the moon and Jupiter on Christmas Eve await those willing to combat December's chill. by Martin Ratcliffe and Alister Ling

The sky always offers something new to observe. It might be a dramatic comet. Perhaps an eclipse, or a fine meteor shower. Then again, it could be a stunning lunar occultation of a bright star. Such transient phenomena add a sense of excitement and anticipation to what may happen next in our brief view of the universe.

The occultation of a star by the moon is an interesting event to watch, especially when the star being occulted is bright. There are only four 1st-magnitude stars that lie along the path of the moon. They are Aldebaran in Taurus the Bull, Regulus in Leo the Lion, Spica in Virgo the Maiden, and Antares in Scorpius the Scorpion.

This month, three lunar occultations of stars take place — two of Aldebaran and one of Regulus. Most observers in the continental United States will be able to see at least one of these events. To see them all, you must be quite mobile — each is visible from a different geographic location.

Aldebaran's two lunar occultations occur on December 3 and December 30. The first event is visible just before dawn from the extreme western regions of the United States. It can also be observed from China, Japan, and the northeastern part of Russia. Observers across most of the western United States will have an added treat. They can see the moon occulting stars in the Hyades during the early morning hours before Aldebaran's occultation, beginning after midnight.

A better occultation of Aldebaran occurs for the eastern half of the United States and all of Europe on the night of December 30/31. The extreme northeastern part of the United States and most of eastern Canada will see the disappearance of this fiery-red star behind an almost full moon. For most of the

The moon and Venus decorate the 1995 Christmas night sky in snowy Montana. This Christmas observers can look for the moon to pair with Jupiter.

John McNeal

DECEMBER 1998

1 Mercury is in inferior conjunction, 10 a.m. EST

2 The moon is at perigee (222,974 miles from Earth), 7:18 a.m. EST

3 The moon passes 0.6° north of Aldebaran, 8 a.m. EST
Full moon is at 10:19 a.m. EST

9 The moon passes 0.01° south of Regulus, 1 a.m. EST

10 Last quarter moon is at 12:53 p.m. EST

12 The moon passes 1.8° north of Mars, 3 a.m. EST

13 Geminid meteor shower peaks (page 78)

14 The moon is at apogee (252,126 miles from Earth), 12:05 p.m. EST

16 Mars is at aphelion (154.9 million miles from the sun), 5 p.m. EST
The moon passes 3° north of Mercury, 7 p.m. EST (page 81)

18 New moon is at 5:42 p.m. EST

19 Mercury is at greatest western elongation (22°), 11 p.m. EST

21 The moon passes 1.7° north of Neptune, 11 a.m. EST
Winter solstice is at 8:56 p.m. EST

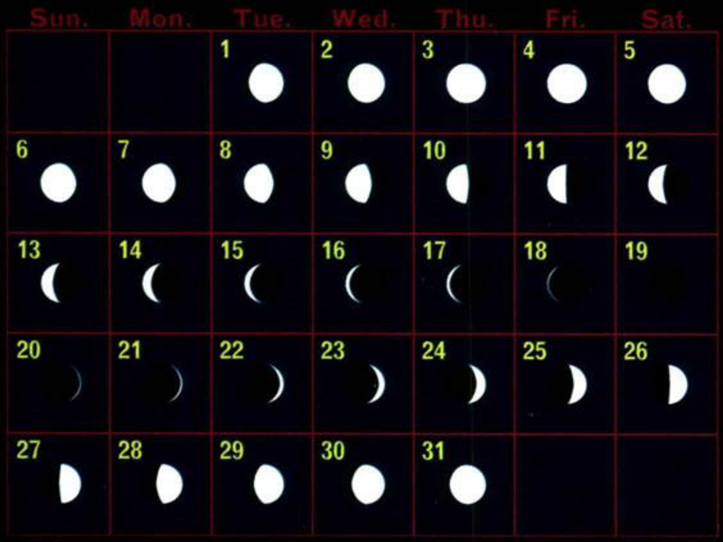
22 Mercury passes 7° north of Antares, 1 a.m. EST
The moon passes 1.8° north of Uranus, 6 a.m. EST

25 The moon passes 1.2° south of Jupiter, 6 a.m. EST

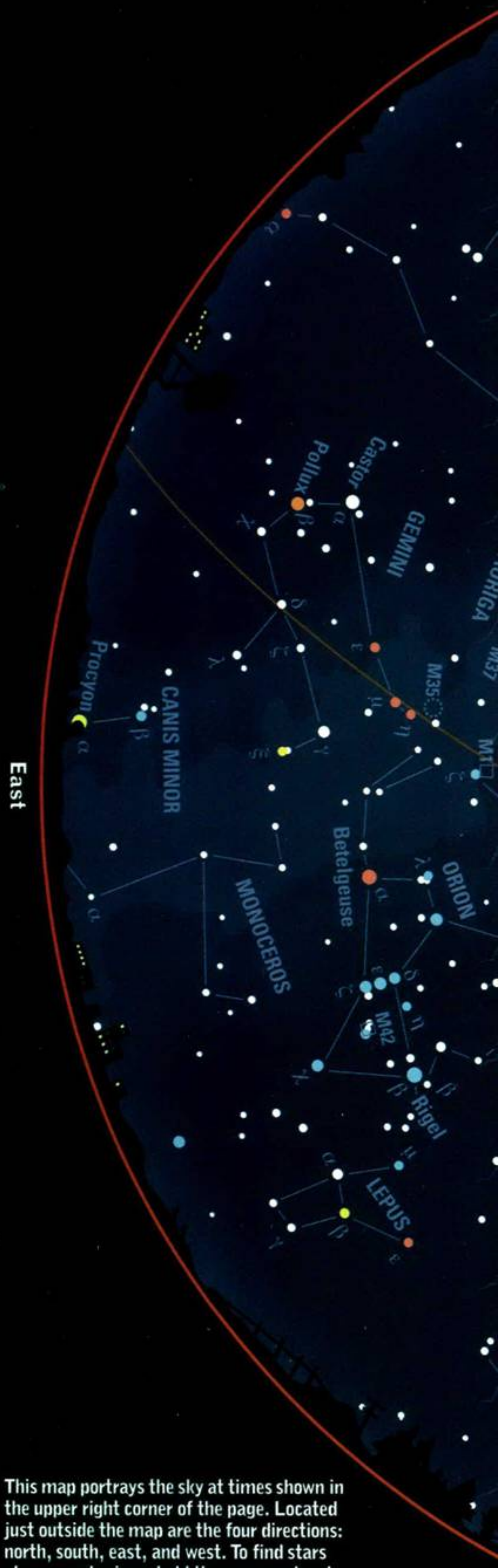
26 First quarter moon is at 5:46 a.m. EST

27 The moon passes 2° south of Saturn, 6 p.m. EST

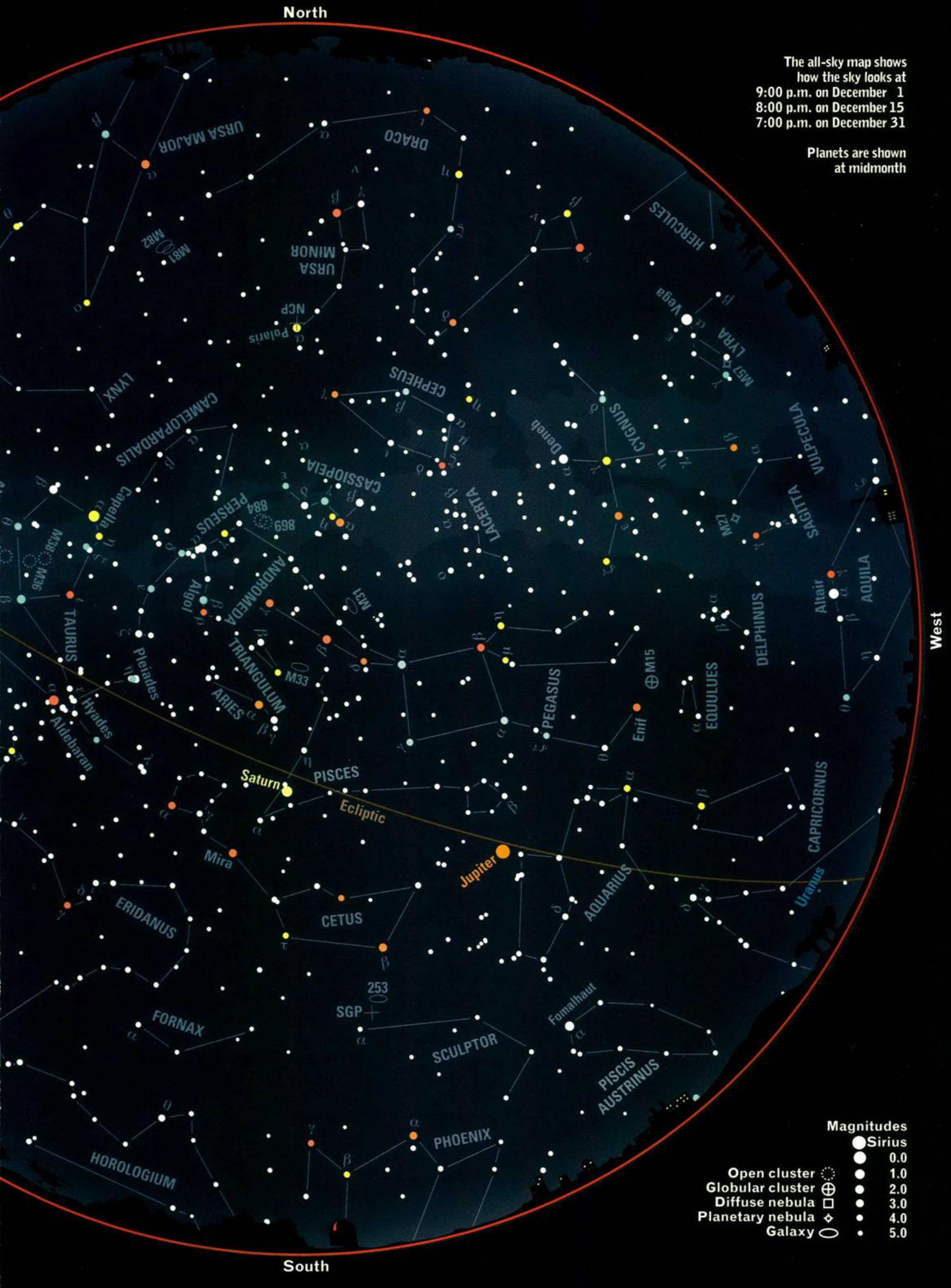
30 The moon is at perigee (226,044 miles from Earth),12:49 p.m. EST
The moon passes 0.6° north of Aldebaran, 6 p.m. EST (page 79)



Sun.	Mon.	Tue.	Wed.	Thu.	Fri.	Sat.
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31		



This map portrays the sky at times shown in the upper right corner of the page. Located just outside the map are the four directions: north, south, east, and west. To find stars above your horizon, hold the map overhead and orient it so a direction label matches the direction you're facing. The stars above the map's horizon now match what's in the sky.

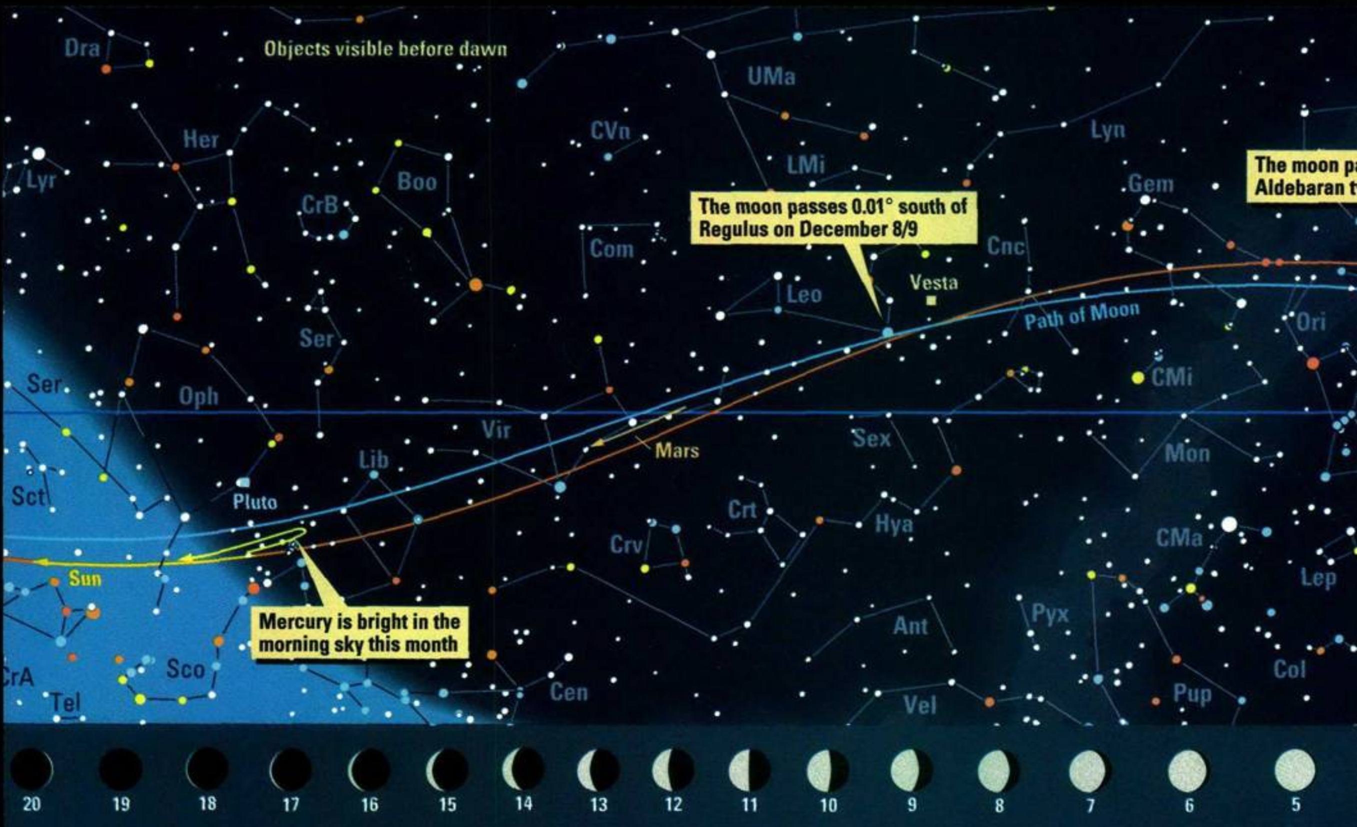


The all-sky map shows
how the sky looks at
9:00 p.m. on December 1
8:00 p.m. on December 15
7:00 p.m. on December 31

Planets are shown
at midmonth

North
South
West
URSA MAJOR
DRACO
M81
M82
URSA MINOR
NCP
Polaris
HERCULES
Vega
LYRA
M57
LYNX
CAMELOPARDALIS
CEPHEUS
CYGNUS
Deneb
VULPECULA
CASSIOPEIA
LACERTA
SAGITTA
M27
Capella
PERSEUS
884
869
M38
M36
ANDROMEDA
Algol
M31
AQUILA
Altair
TAURUS
Pleiades
TRIANGULUM
M33
M15
DELPHINUS
EQUULEUS
PEGASUS
Enif
Hyades
Aldebaran
ARIES
Saturn
PISCES
Ecliptic
CAPRICORNUS
Mira
Jupiter
AQUARIUS
Uranus
ERIDANUS
CETUS
253
SGP
FORNAX
Fomalhaut
SCULPTOR
PISCIS AUSTRINUS
PHOENIX
HOROLOGIUM
Magnitudes
Sirius
0.0
1.0
2.0
3.0
4.0
5.0
Open cluster
Globular cluster
Diffuse nebula
Planetary nebula
Galaxy

THE PATH OF THE PLANETS


Dra
Objects visible before dawn
UMa
Her
CVn
Lyn
Lyr
LMi
Boo
CrB
Gem
Com
Cnc
Leo
Vesta
Path of Moon
Ori
Ser
CMi
Ser
Oph
Vir
Sex
Mars
Mon
Lib
Sct
Pluto
Crt
Hya
CMa
Crv
Sun
Lep
Pyx
Ant
Sco
rA
Tel
Cen
Vel
Pup
Col
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5

The moon passes 0.01° south of Regulus on December 8/9

The moon pa
Aldebaran t

Mercury is bright in the morning sky this month

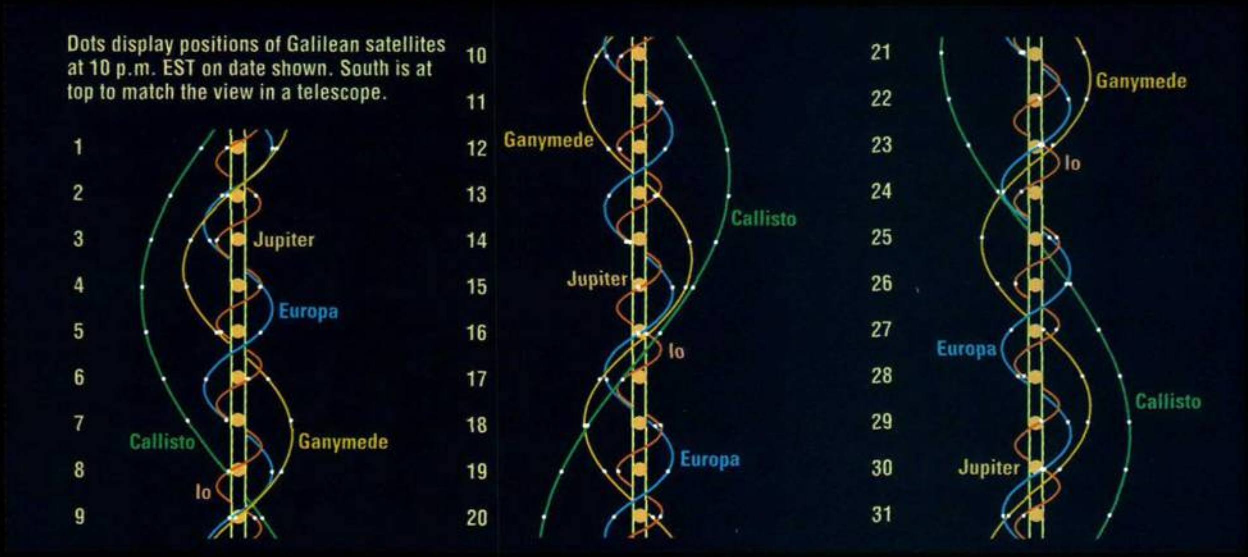
To locate the moon in the sky, draw a line from the phase shown for the day straight up to the curved light-blue line.

10"

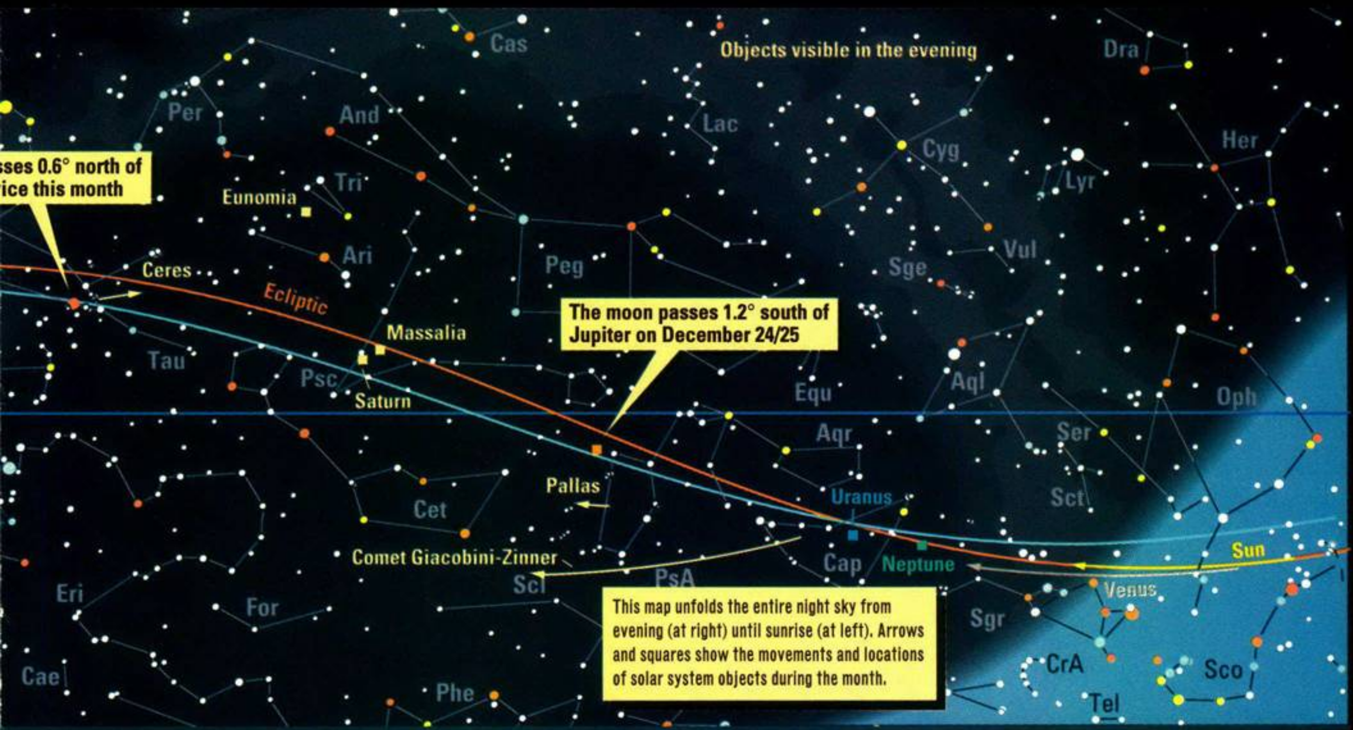
S
W E
N

PLANETS	MERCURY	MERCURY	VENUS	MARS	JUPITER
Date	December 15	December 31	December 15	December 15	December 15
Magnitude	−0.1	−0.4	−3.9	1.2	−2.4
Angular Size	7.5"	5.5"	10.0"	5.6"	40.1"
Illumination	46%	83%	98%	91%	99%
Distance (AU) from Earth	0.897	1.215	1.667	1.659	4.910
Distance (AU) from Sun	0.347	0.432	0.728	1.666	4.958
Right Ascension (2000.0)	16h03.5m	17h16.3m	18h17.9m	12h38.3m	23h24.7m
Declination (2000.0)	−18°02'	−22°20'	−24°11'	−2°11'	−5°13'

JUPITER'S MOONS



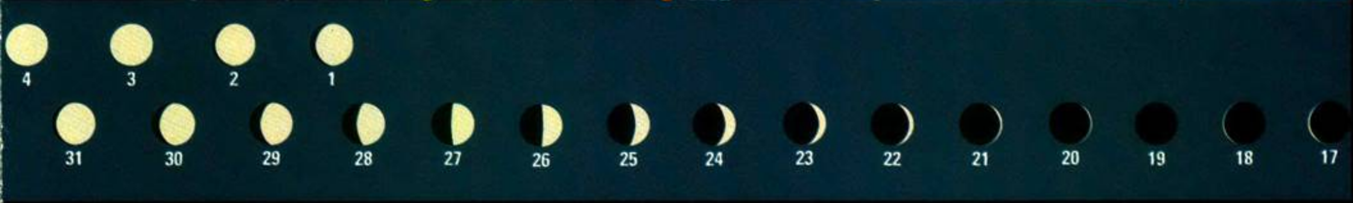
Dots display positions of Galilean satellites at 10 p.m. EST on date shown. South is at top to match the view in a telescope.


Cas
Objects visible in the evening
Dra
Per
And
Lac
Cyg
Her
Tri
Lyr
Eunomia
Ari
Vul
Peg
Sge
Ceres
Ecliptic
Massalia
Tau
Psc
Saturn
Equ
Aql
Oph
Aqr
Ser
Pallas
Cet
Uranus
Sct
Sun
Comet Giacobini-Zinner
Scl
Cap
Neptune
PsA
Venus
Eri
For
Sgr
CrA
Sco
Cae
Phe
Tel

sses 0.6° north of
ice this month

The moon passes 1.2° south of Jupiter on December 24/25

This map unfolds the entire night sky from evening (at right) until sunrise (at left). Arrows and squares show the movements and locations of solar system objects during the month.


4
3
2
1
31
30
29
28
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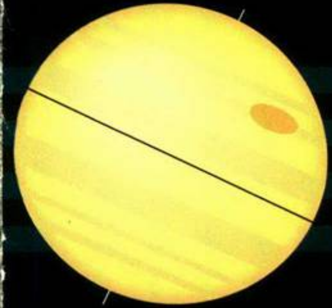
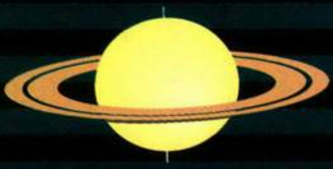
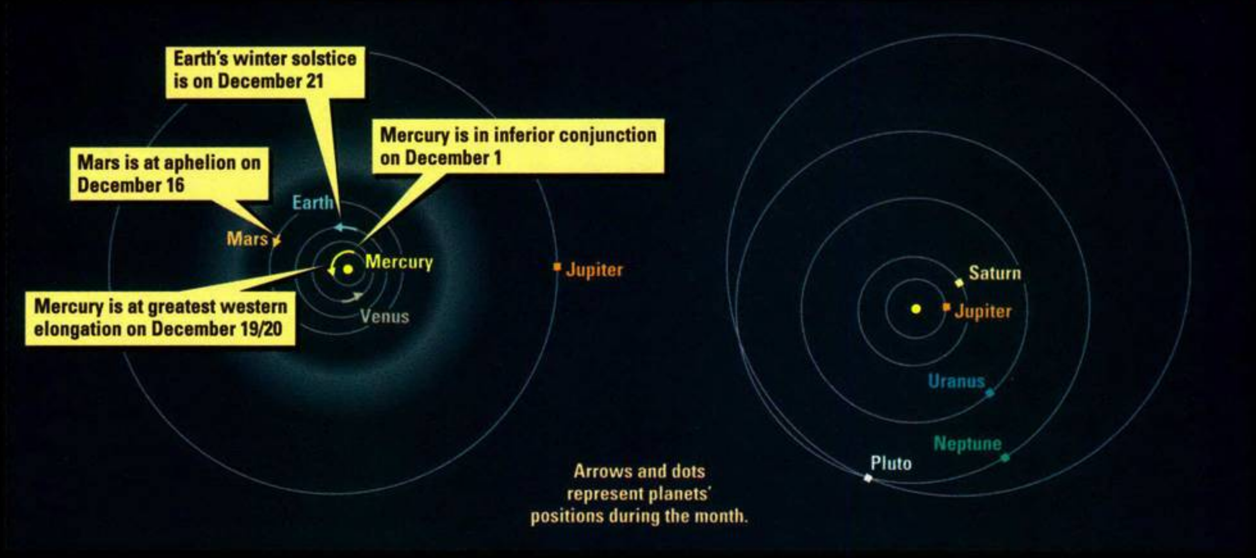
19
18
17





SATURN	URANUS	NEPTUNE	PLUTO
December 15	December 15	December 15	December 15
0.2	5.9	8.0	13.9
19.1"	3.4"	2.2"	0.1"
100%	100%	100%	100%
8.686	20.538	30.907	31.050
9.274	19.884	30.134	30.117
1h44.0m	20h51.1m	20h10.5m	16h34.3m
7°57'	–18°19'	–19°45'	–10°29'

THE PLANETS IN THEIR ORBITS


Earth
Mars
Mercury
Jupiter
Venus
Saturn
Jupiter
Uranus
Neptune
Pluto

Earth's winter solstice is on December 21

Mercury is in inferior conjunction on December 1

Mars is at aphelion on December 16

Mercury is at greatest western elongation on December 19/20

Arrows and dots represent planets' positions during the month.

FIRST VIEWS: The Demon Star

How times have changed. Today, astronomers enjoy investigating objects that vary. Hundreds of years ago, people believed the stars were perfect and unchanging. If something in the sky did alter, it was a bad omen. The demon star, Algol (Beta [β] Persei), is just such a star.

The Arabs were the first to nickname Algol the Demon, but the name easily fit into Greek star lore as well. To the Greeks, Algol represented one of Medusa's eyes. It rests in her ghastly head that Perseus severed and now carries triumphantly across the heavens.

As the Renaissance unfolded, Algol was closely watched and timed. Early astronomers found the star to vary in a consistent 2.8-day cycle.

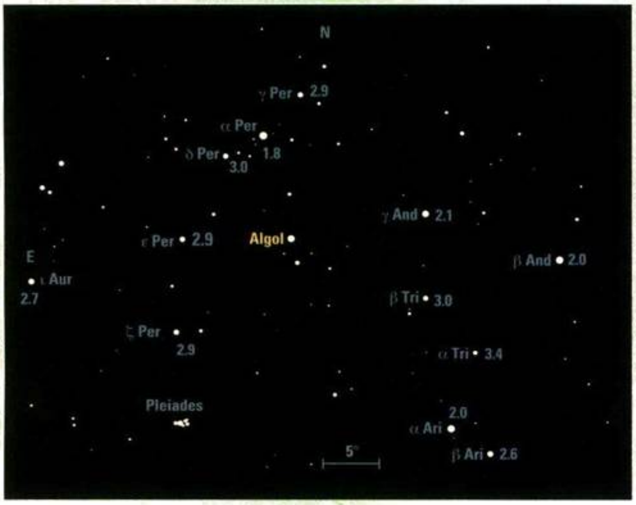
Algol is a mild-mannered eclipsing binary. The two stars circle each other in a tight gravitational embrace. Once each orbit, one star partially hides (eclipses) the other from view, and Algol quickly drops from its normal brightness. The change is apparent over the course of an evening. Try your hand at detecting the cycle by using other stars in the sky to judge Algol's brightness.

Hal R. Jandorf

If the Demon entices and observing more variable stars is what you seek, visit the American Association of Variable Star Observers (AAVSO) website at http:// www.aavso.org.

The following list gives dates and times of Algol's minimum brightness for December. Bold values are good evening events for North America. Times are given in Universal Time (subtract five hours for EST, six for CST, seven for MST, and eight for PST). Start watching about three hours before the predicted minimum brightness.

Dec 2 3h 06m, **Dec 4 23h 55m**, Dec 7 20h 44m, Dec 10 17h 33m, Dec 13 14h 22m, Dec 16 11h 11m, Dec 19 8h 00m, **Dec 22 4h 50m**, **Dec 25 1h 39m**, **Dec 27 22h 28m**, Dec 30 19h 17m.



Illustrations by *Astronomy*: Elisabeth Rowan

eastern half of the continent, the moon will not have risen locally to see the onset of the occultation. These observers will, however, see the reappearance of Aldebaran in a darkening sky. Those living farther west see the event in twilight. Observers in England and continental Europe have a perfect nighttime view of the entire occultation. Like Aldebaran's December 3 occultation, stars in the Hyades will also be occulted before the bright star.

The third major lunar occultation of the month happens in the skies over Florida on Wednesday, December 9. Those in the southeastern United States have the opportunity to see Regulus disappear behind a waning gibbous moon shortly after midnight.

Regulus is the brightest star in the constellation Leo the Lion. It marks the period in the backward question mark that denotes Leo's head and mane. It is also the star that marks the heart of the Lion.

Another highlight this month are the shooting stars of the Geminid meteor shower. The term "shooting star" is a fine misnomer. It conveys an image of a sky full of dazzling streaks of light. In reality, these streaks are caused by specks of dust that barrel into Earth's atmosphere. There they vaporize and produce wondrous streaks across the sky. The correct name for these pieces of vaporizing dust or rock is *meteor*.

During this month's Geminid meteor shower, an observer might see up to 100 meteors per hour. On a typical night, the Geminids produce 70 per hour.

Dust from a bygone comet produces this transient display. The Geminids appear to radiate from a point in the constellation Gemini the Twins. The shower is active December 7–17, with maximum rates occurring around December 13. At this year's peak, the moon is a mere five days before new, so its light will not interfere with the spectacle. Wrap up the children in warm clothes and take the family out to experience the splendor of this fine shower.

Before you observe the Geminids, take time during the early evening hours to observe the planets. Jupiter, Saturn, and Mars are all easy to find. Mercury and Venus present observers with a bit of a challenge as one emerges from the sun's glare while the other succumbs to it.

Jupiter is the first to attract attention with its brilliance. Shining at magnitude –2.4, the planet is hard to miss among the stars of Aquarius. After sunset, it stands high in the south-southeast, and by December's end it lies due south at dusk. The planet's position in our sky allows for at least three to four hours of good viewing before it sets after midnight.

Strange things are happening in the jovian atmosphere, and these events have Jupiter watchers very excited. Last May, two of the well-known white ovals merged into one large oval. Following that observation, the summer revealed a new dark spot in the South Temperate Belt (STB). Then, the South Equatorial Belt (SEB) dramatically appeared to be split in two parts.

Jupiter is always a major attraction, but this year it has put on quite a show. Each evening new activity in the atmosphere can be tracked by observers with small telescopes. On Christmas night, look for a large crescent moon roughly 5° away from the brilliant planet. This meeting presents a fine pair of objects to try out that new telescope you may have received as a gift.

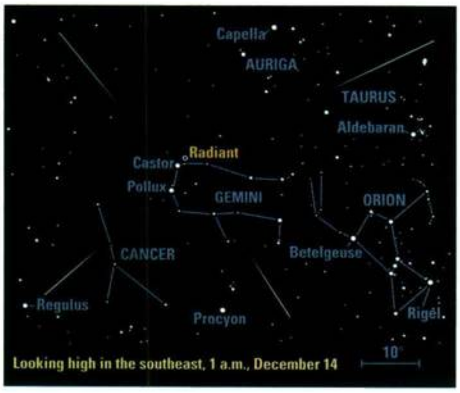
December's Gems

The premier astronomical event of December is without question the annual Geminid meteor shower. As Earth cuts through a swath of ancient comet dust, the particles get caught by Earth's gravity. Their 22-mile-per-second (35 km/s) impacts with the upper atmosphere yield final flashes of glory as they vaporize across the sky.

Bill Hutchinson

On the night of December 13/14, gather friends, deck chairs, sleeping bags, and warm drinks while you prepare to watch the often bright fireballs that this reliable shower produces. Don't forget binoculars to watch the trails twist in the upper winds.

The meteoroids or dust particles actually travel in parallel, but thanks to Earth's motion through the dust patch, the "shooting stars" appear to emanate from a point (the radiant) near Castor and Pollux. Think of a pair of railway tracks that appears to emanate from a point on the horizon and you'll better understand the effect.



Looking high in the southeast, 1 a.m., December 14

The moon is now past third quarter and will not hinder the show this year. Observers at dark sky sites should see a maximum of 60–80 meteors per hour. Because this shower produces frequent bright meteors, those who wish to stay close to home in the city may still be able to enjoy 15–20 meteors per hour — more than the fainter Perseids.

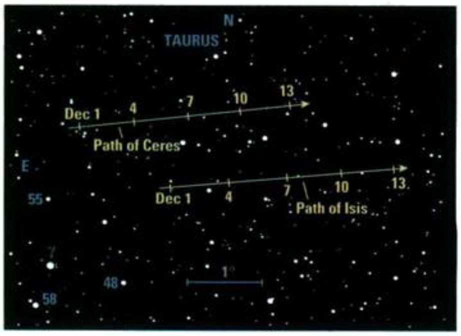
Asteroids in the Hyades

Asteroid fans have more to watch this month. Two hunks of interplanetary rock glide silently through the sky near the Hyades and only 2° apart.

Roughly 600 miles (1,000 km) across, 1 Ceres is by far the largest asteroid. It's not very close to Earth during this opposition, yet Ceres still shines at 7th magnitude and is readily visible in binoculars from the city (see "Ceres Pierces the Hyades," p. 106).

A full 10 times smaller than Ceres is 42 Isis. It was discovered by British astronomer Norman Robert Pogson in 1856 — some 55 years after Giuseppe Piazzi discovered Ceres.

The smaller surface of Isis means its brightness is notably less. To see its 10.5-magnitude glow, you'll need to observe from one night to the next to confirm which "star" moved.



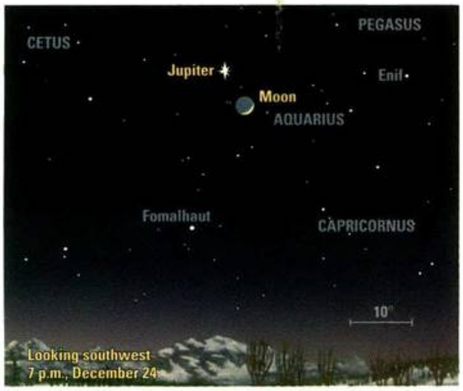
Isis is roughly 25 million miles (40 million km) closer to Earth than is Ceres. Otherwise, this small rock would be even tougher to spot.

Christmas Delight

Why not give your family and friends a little extra Christmas gift this year? The moon and Jupiter present a beautiful early evening pairing.

First a challenge, a 22-hour-old crescent moon hovers alone in the sky on December 19. It will be low in the west soon after sunset. On the West Coast, it's a bit older (25.9 hours) and easier to spot. Venus, practically lost in the sun's glare, is 3° to the left. Chances are you'll need binoculars and very clear air to see it.

Gianni Tumino



From December 20 to 23, the crescent moon is a beautiful sight. Look for reflected sunlight from Earth to round out the moon's shape. This effect is called earthshine, and it makes the darker portion of the moon seem brighter. On Christmas Eve, the moon forms a wide pair with Jupiter and is sure to evoke poetic comments from many observers.

On December 27, Saturn pairs with the waxing first quarter moon. On that date, the two will be separated by only 3.5°.

The Winking Bull

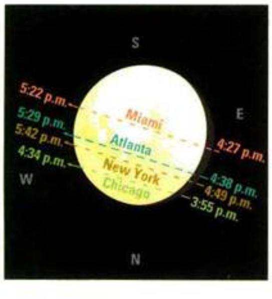
Over the last few years, the moon's slowly changing path through the sky has brought it near to Aldebaran. This red-orange eye of Taurus the Bull occasionally blinks as the moon passes over it. Parts of North America see this happen twice in December.

Alberto Levy

On the night of December 2/3, the moon begins by gobbling up various Hyades stars. The show begins around 1 a.m., and for those on the West Coast, culminates in an occultation of Aldebaran just before moonset and sunrise.

One sidereal lunar month later, on December 30, the moon hides Aldebaran for observers in the eastern third of the continent. This event occurs at a much more civilized hour beginning at approximately 4:30 p.m. EST. Visit the International Occultation Timing Association website at http://www.sky.net/~robinson/iotandx.htm for exact times of disappearance and reappearance in your area.

Lucky observers on a line from Fargo, North Dakota, northeastward through the Canada-Minnesota border have a chance to watch a spectacular graze of Aldebaran. The moon's mountains and valleys will alternately hide and uncover the red giant. Because Aldebaran is so large, these events are noticeably longer than the blink of an eye, as is the case for smaller stars.



In the neighboring constellation Pisces, the sixth planet from the sun, **Saturn,** lingers quietly. Its magnitude drops by one-tenth this month to magnitude 0.2. The moon skirts 2° south of Saturn on December 27. If there is any object that will justify that holiday gift of a telescope, Saturn is the one to deliver. Its majestic set of rings will astound the new observer immediately. Saturn's southern ring face is currently on view. The planet's tilt and orbit will give the rings the appearance of widening until 2002.

Saturn takes 29 years to complete one orbit around the sun, while Jupiter takes only 12 years. The two planets will appear close together over the next couple of years, as their orbits bring them to the same part of our sky. Jupiter finally overtakes Saturn in their easterly race in the year 2000.

After observing Saturn, look south of the planet to see the first variable star discovered, Mira (Omicron [o] Ceti). This well known variable is a pulsating red giant. The star lies southwest of the circlet of five stars that form Cetus the Sea Monster's head.

Since Mira reached its minimum magnitude of 9 in August, the star has been increasing in brightness. If predictions hold, it will reach its maximum on December 11.

Variable stars are well-known for their idiosyncrasies. In this case, the depth of our knowledge is only as good as the last observation. In 1969 it attained a magnitude of 2.1. In 1779 it reportedly rivaled the star Aldebaran. This year Mira is predicted to reach 3rd or 4th magnitude.

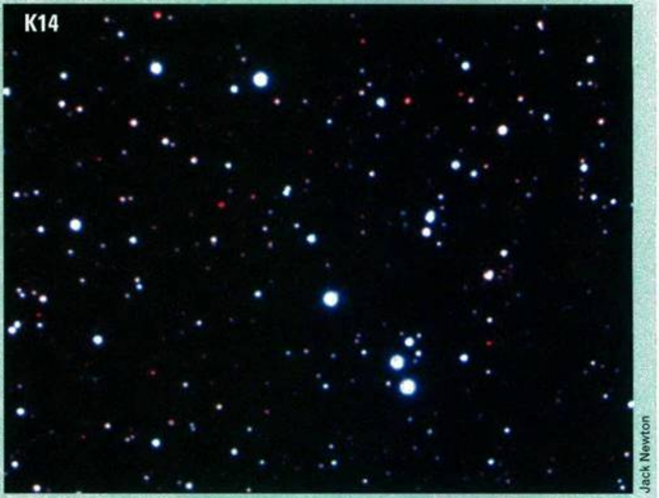
Observer's Challenge: The King Clusters

Cluster fans take note. The King series of open star clusters consists of many rich objects. Sir William Herschel and his son Sir John Herschel discovered most of the familiar star clusters and many more are listed in the NGC catalog. However, the Herschels overlooked a couple of bright clusters that fell into the sights of Ivan King as he scanned the Palomar Observatory Sky Survey.

King 14 is one of a trio of open star clusters near Kappa (κ) Cassiopeiae, while King 12 is the last of a line of five clusters just northwest of Beta (β) Cassiopeiae. These two are examples of Ivan King's brighter, sparser, open clusters.

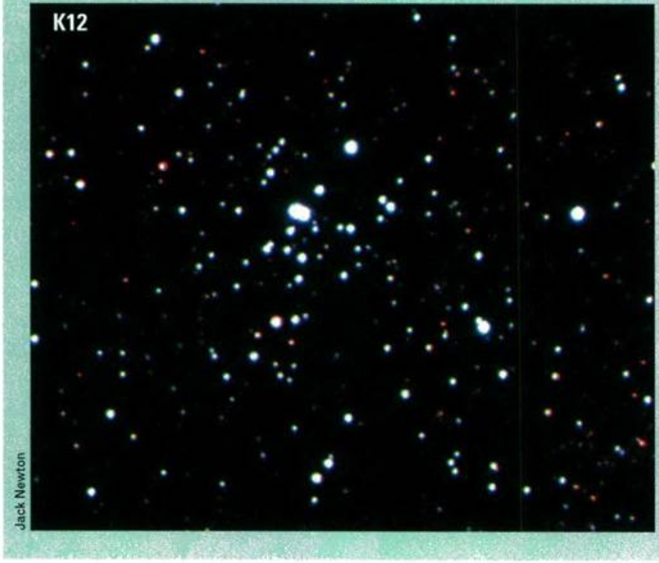
Most King clusters are typically rich and hold more than 100 stars. Though these clusters have quite a few stars, they are still quite faint. To resolve these King clusters, you'll need dark skies and at least a 10-inch telescope. Some of the King clusters will need even more aperture. To find these objects, a deep-sky software package like *Guide* or *Megastar* is helpful. These programs can generate finder charts for your observing sessions.

K14



Jack Newton

K12



Jack Newton

My favorite winter King cluster is King 17 in Auriga the Charioteer. It can be found just south of the three stars called "The Kids." With an 8-inch SCT, King 17 looks like a small faint comet. In a 12-inch scope, some granulation can be seen at a magnification of 65x. Increasing the magnification to 200x reveals a somewhat triangular shaped grouping that is preceded by a tiny line of stars right along the base. The stars are more crowded in the middle.

An additional adornment in the low-power field is the delightful rusty-orange variable star TX Aurigae. Look for King 17 at a right ascension of 5h08.4m and a declination of 39°03' (2000).

While you're out observing Saturn and Mira, take time to look at Algol (Beta [β] Persei). It lies high above Cetus in the constellation Perseus. Like Mira, Algol too is a variable star, but its brightness changes come from a faint orbiting companion that occults the brighter star. Observing this type of variable has its advantages. Algol changes its brightness over a few hours rather than months or years.

Watch Algol beginning at nightfall on December 2 and on December 22. Compare the star's brightness to that of its neighbors every half hour. By late evening on both occasions the star will dim noticeably from magnitude 2.1 to magnitude 3.4.

Perseus passes overhead around 10 p.m. local time early in the month. To its east lies the Chained Maiden, Andromeda. Over several hours during winter evenings, Andromeda slowly descends to the west along with Pegasus, Aquarius, and Pisces. Perseus is the hero who saved Andromeda from the Sea Monster's jaws. Also to the east of Perseus is the bright yellow gem Capella in Auriga the Charioteer.

The winter Milky Way, rather faint from Auriga south to Gemini and Orion, dominates the eastern half of the sky. This region is teeming with open star clusters and holds the Great Orion Nebula (M42). Orion is followed by the stars Sirius and Procyon. These two stars mark the heads of Orion's hunting dogs. They, with Orion's right shoulder star Betelgeuse, form the Winter Triangle.

The other planets in our solar system put on varied displays this month. You might try to spot **Venus** at magnitude –3.9 soon after sunset late in December. With a clear western horizon on December 19, it might be possible to glimpse a 24-hour-old moon 4° to the north of Venus. West Coast observers will have a slightly better chance of seeing the pair.

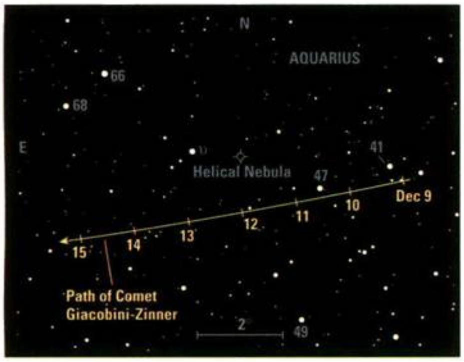
Comet Giacobini–Zinner

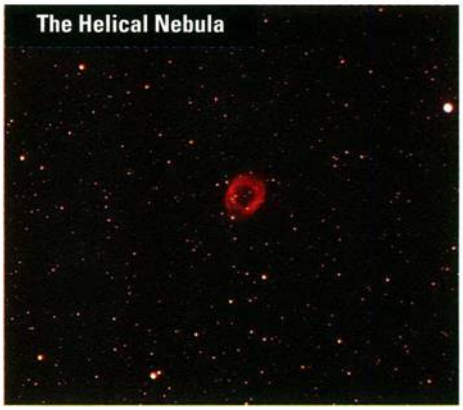
Get out your camera and head to a dark sky site. The slowly retreating Comet Giacobini–Zinner is sliding past the large Helical Nebula, NGC 7293.

By the second week of December, the moon rises later in the evening. Before then its light will wash out the fading 9th-magnitude comet.

On Friday evening, December 11, Giacobini–Zinner can be found within 2° of the Helix. Don't despair if it's cloudy, the comet is moving slowly and stays within 5° of the nebula for up to five days before or after the 11th.

To photograph Giacobini–Zinner, it's best to have a tracking platform. Exposures of at least a few minutes will be necessary, and sharp images cannot be obtained without tracking the comet.




The Helical Nebula

Mace Hooley

To see Giacobini–Zinner, start at low power to locate the comet. How far can you trace its stubby tail? Increase the magnification and check the inner coma for jet activity. The comet's closest approach to the sun was November 21, so there may be some jet activity to see in the coma.

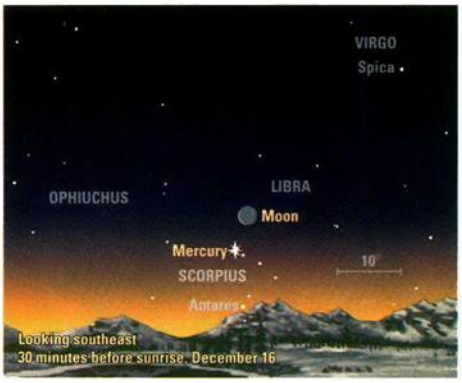
Be prepared for an early outing. Darkness falls by 5:30 p.m. when the comet is roughly 15° above the horizon. The farther north you live the lower Giacobini–Zinner will be.

Morning Mercury

Not to be outdone by the events in the evening sky, Mercury puts on a show for morning observers. The planet emerges from the sun's glare low in the southeast by December 11. If you point a telescope toward this swift planet, you will see a 30-percent-sunlit crescent roughly 8" across.

The star Antares is still on the horizon near to Mercury. You can positively identify the planet because it is the only 0-magnitude object in that part of the sky.

On December 16, a slightly thinner crescent moon hangs 6° above Mercury. Notice how each object has nearly the same color. Through the telescope, the crescent Mercury looks very similar to the crescent moon. In fact,the flyby images taken by Mariner 10 can easily be mistaken for the moon.



Looking southeast
30 minutes before sunrise, December 16

A thin crescent moon, just 30 hours before new, points its horns toward Mercury on December 17. The moon is only 6° lower than the planet. On this date, Mercury's phase is past crescent and headed toward full later this month.

Mercury has a fair appearance in the early morning sky at month's end. It passes through inferior conjunction on December 1 then rapidly moves away from the sun, increasing its altitude above the eastern dawn horizon. Mercury's greatest elongation west (22°) of the sun occurs on December 19/20. On December 26 it rises at the same time as the star Antares in Scorpius — a full hour and a half before the sun.

Though **Mars** reserves its best show until the New Year, it still offers some nice views. This month, the Red Planet can be found in the early morning sky in the constellation Virgo the Maiden. It passes near Eta (η) Virginis on December 6 and south of the famous double star Porrima (Gamma [γ] Virginis) on December 16. It ends the month standing 7° to the northwest of Spica.

Spica is a white star. Its contrasting color creates a beautiful image with the orange/red glow of Mars. By December 31, Mars and Spica both shine at 1st magnitude. Through a telescope, however, Mars remains a disappointing 6" across. During the first four months of the new year, Mars will see a dramatic change in size as it approaches its 1999 opposition on April 24. It will also steadily increase in brightness over the next few months. At the planet's time of opposition, it will have a magnitude of –1.7. ■

Martin Ratcliffe is Director of Theaters at the Exploration Place in Wichita, Kansas. Alister Ling is a meteorologist working for Environment Canada in Alberta.

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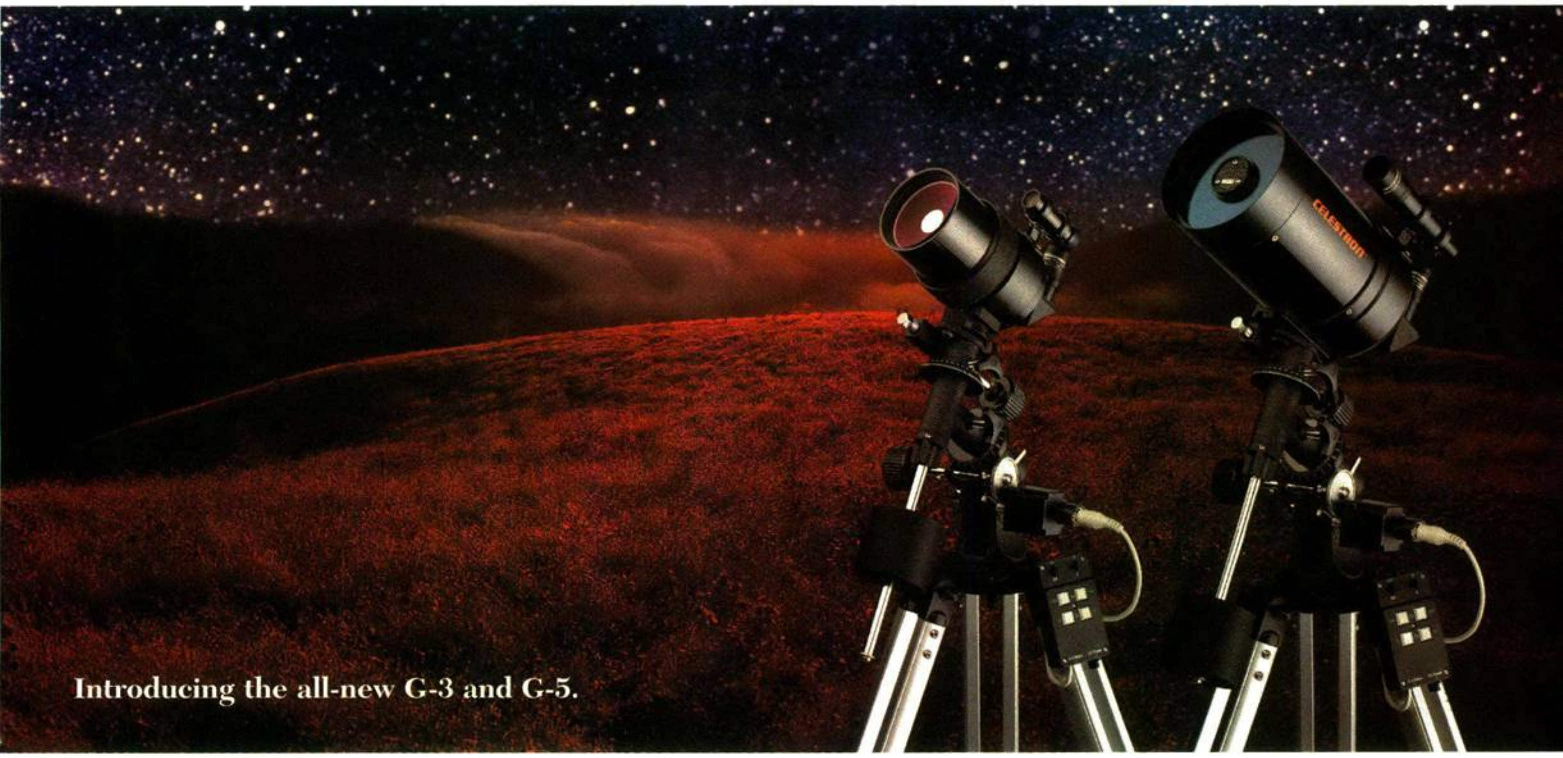

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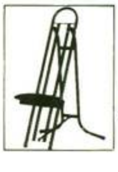

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Mention Ad A-7

Gifts for Budding Astronomers

"He's makin' a list, checkin' it twice, gonna find out who's naughty or nice. Santa Claus is coming to town." . . . In my childhood home there was a chimney but no fireplace. Where the fireplace once stood, a wall had been built. And in front of that wall stood an enormous and immovable piece of furniture that reached almost as high as the ceiling. As soon as I was old enough to analyze the situation, I began to wonder how Santa was able to get inside my house without moving any furniture or leaving any holes in the wall. And yet the presents kept piling up, not only under my tree but under trees around the world. I smelled a scam.

Whether or not your children believe in Santa Claus, whether your winter celebration is Christmas or Hanukkah or Kwanza or Three Kings' Day, if gift giving is involved, you'll want to take a look at this list of terrific presents for budding young astronomers. And whatever you seek, be it for the bookshelf, the VCR, or the toy chest, we've got a suggestion.

By Jeanette Brown

On the Shelf

Shelves containing treasured books take center stage in many households. If your younger generation fancies astronomy, there are a few books that deserve places in your library.

First consider the "Starting With Space" series from Kids Can Press. This fall two new titles, *The Planets* (ISBN 1-55074-512-3) and *The Stars* (ISBN 1-55074-524-7), joined the three original titles, *The Sun* (ISBN 1-55074-158-6), *The Moon* (ISBN 1 55074-157-8), and *The Earth* (ISBN 1-55074-314-7). Together these five books form a valuable collection of educational texts for young children. Written by Cynthia Pratt Nicolson and illustrated by Bill Slavin, the books share a similar style and design: Clear, imaginative prose weaves history, geology, astronomy, and lore into a narrative your child will follow eagerly while detailed illustrations and the latest color photos from NASA, Hubble, and Mars Pathfinder enliven the text. Intended as educational tools for children between the ages of seven and ten, the books each contain numerous hands-on activities to help build understanding of important concepts. Though the five titles together form a comprehensive collection for your child's library, each book can stand alone as well.

A second publisher joins in the literary action with *Welcome to the Moon* by Robert Bruce Kelsey (ISBN 87961-245-2), Naturegraph Publishers. This inviting book is a good gift for young astronomers who already have a small telescope. With Kelsey's guidance, your child can embark on twelve expeditions to exciting lunar features without a large telescope and even without ideal viewing conditions. What's more, the lunar features your child will be seeking in his or her telescope are clearly illustrated with drawings made from the author's own small 4.5-inch telescope. The book serves as a wonderful educational guide: An early chapter teaches how to find distant objects effectively, and the book treats the history and geology of the moon as a mystery for your child to unravel. How were lunar seas created? How do you determine the age of craters? What are the moon's mountain ranges like? The search for answers to these and other questions will make a little Sherlock Holmes of your child, and Kelsey has arranged the activities in a way that gradually builds observational skills.

All photos *Astronomy*: William Zuback

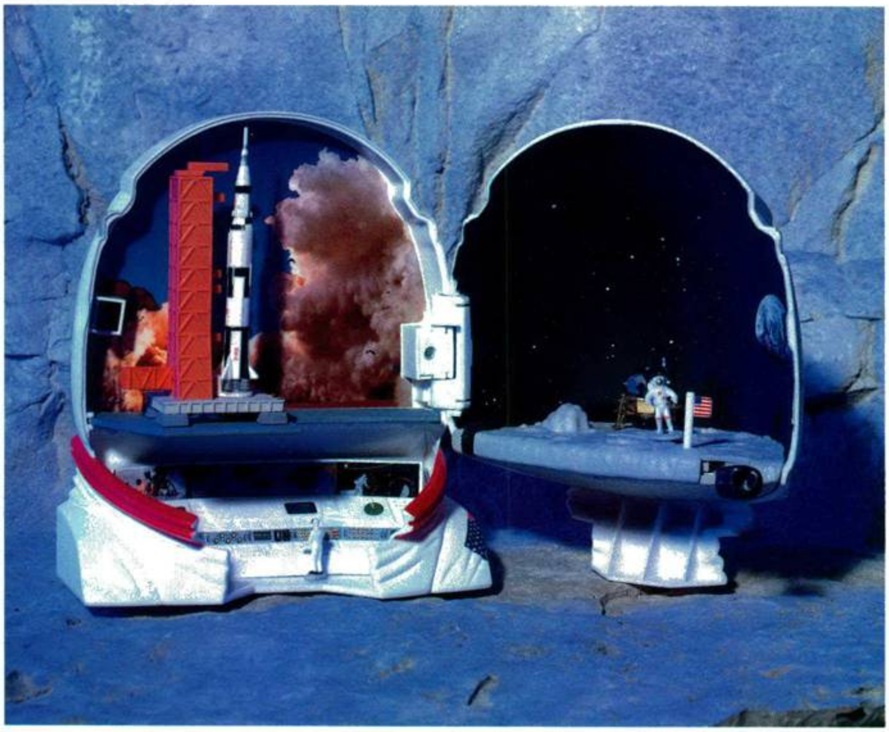
McKenzie (top left), Joshua, Karly, and Kayla share the "Starting With Space" book series.

The second title from Naturegraph, *Making a Clock-Accurate Sundial* by Sam Muller (ISBN 87961-246-0), takes the Earth's tilt and orbit, ideas often too complex and abstract for young children to comprehend, and makes them easy to understand. By following simple directions, children can construct a basic sundial that they can then use to witness and begin to understand Earth's motion. Additional activities, most using a globe, are also provided and help illustrate concepts like daylight savings time, standard time, latitude and longitude, time zones, and lunar motion. By involving kids in fun activities designed to help them learn, Muller makes teaching difficult concepts very easy work.

If your children are older, however, you might want to consider the newest book by Hayden Planetarium director Neil de Grasse Tyson. *Just Visiting this Planet: Merlin Answers More Questions about Everything Under the Sun, Moon, and Stars* (ISBN 0-385-48837-8) is Tyson's follow-up to the tremendously successful *Merlin's Tour of the Universe.* Merlin, Tyson's alter-ego, is on a research assignment from his homeland — the planet Omniscia in the Andromeda Galaxy. He's been around since the creation of Earth, and though he's an alien academic, he possesses an incredible knack for answering the questions of everyday earthlings with remarkable clarity and simplicity. Did you know that the odds of breathing in the same air molecule twice in our lifetime is one in six quadrillion, or that a frying pan on your roof will collect one ounce of space debris in 300 million days? Regular earthlings fire questions at Merlin, and Merlin responds intelligently on topics ranging from exploding stars and hurtling meteors to the science of retrograde motion and curved space.

Fun and Games

Though they'll appreciate the books down the line, many children fall asleep on Christmas Eve dreaming not of encyclopedias and dictionaries (or even of dancing sugar plums) but of toys, toys, and more toys. Have no fear, even astronomy has toys to offer.



When closed, the *Mission: Blast Off!* transforming action set looks just like a space helmet.

Galoob, working in conjunction with *National Geographic* magazine, has recently released a toy line of transforming action sets that include several with astronomical themes. Entitled the *Micro Machines National Geographic Collection*, mini figurines depicting moon explorers and space pioneers are available, and additional figurines will be added in the upcoming year. Also available is a space-helmet-shaped carrying case to hold your child's entire collection — a better option than say, the bedroom floor. These toys, though not specifically educational in design, can serve to get young kids excited and thinking about space and astronomy.

Next on the list is an item touted by manufacturers as "a whimsical indication of future trends." The *New Moon Walker* from OWI Incorporated heralds trends that indeed may already have arrived. After Sojourner's trek across the surface of Mars, what child wouldn't want his or her own roving robot? The *New Moon Walker* begins to walk when it detects a change in light intensity or receives a sound command. It then continues on its journey, albeit an awkward and wobbly one, until instructed to stop by an internal timer. What's more, it offers your child an exciting challenge just in the building. *New Moon Walker* kits are available for two levels of assembling experience, intermediate and advanced.

To try out the final toy, I decided to call in the cavalry. Thanks go to my three red-headed cousins, Douglas, Aubrey, and Jordan, for putting *MOONSHOT: The Game* to the test. (Really, we thank three-year-old Jordan for not interfering too much as Aubrey, Douglas, and I gave it a go). *MOONSHOT: The Game* is an adventure board game manufactured by the Galactic Attic in which players compete to be the first to successfully complete six lunar missions and reach the moon. To complete a mission, a player must use his or her fuel supply (special playing cards serve as fuel and each player receives an allotted amount at the start of the game) to launch the mission's required equipment (also playing cards, which are drawn at the beginning of each turn) and move his or her playing piece to the mission's corresponding patch on the game board. Once the mission is completed, the player collects a mission patch and gains more fuel. The more fuel you have, the faster you can complete missions.

Just as players get into the swing of the game, variables are thrown in to make things more exciting. Three additional cards — events, alarms, and instants — wreak havoc with the otherwise orderly progression of the game. These special cards correspond to historical events and can be played against opponents to slow their progress toward mission completion. One such card can be used to abort an opponent's Mercury mission — when Aubrey attempted to play it just as his brother Douglas was about to complete his sixth mission to win the game ... things got pretty heated. Parents beware: This can be an explosive game

The *Micro Machines National Geographic Collection* of moon explorers and space pioneers.

and it can go on for hours. But it teaches a great deal of history about the race to the moon, and it dishes out some lessons about the politics and economics involved. The game is intended for up to four players, ages ten and older (though Aubrey, age seven, had no trouble playing along). Instructions for one-player solitaire are included as well.

Just Press Play

Some children, perhaps true children of the Information Age, respond much more readily to images on a screen than to words on a page. With this in mind, the Finley-Holiday Film Corporation has turned its attention toward educational videotapes, some treating astronomical topics. Their newest title, "Mars: Past, Present, and Future — The Complete Story of the Red Planet," was written and produced by Clayton Sandell and narrated by Joseph Campanella. The video is not specifically geared toward children, but older children and even more precocious younger ones will still find the information remarkably accessible. There are no "kiddie" gimmicks employed (the narrator is not a large purple dinosaur), and the topic alone will be enough to capture the attention of most kids.

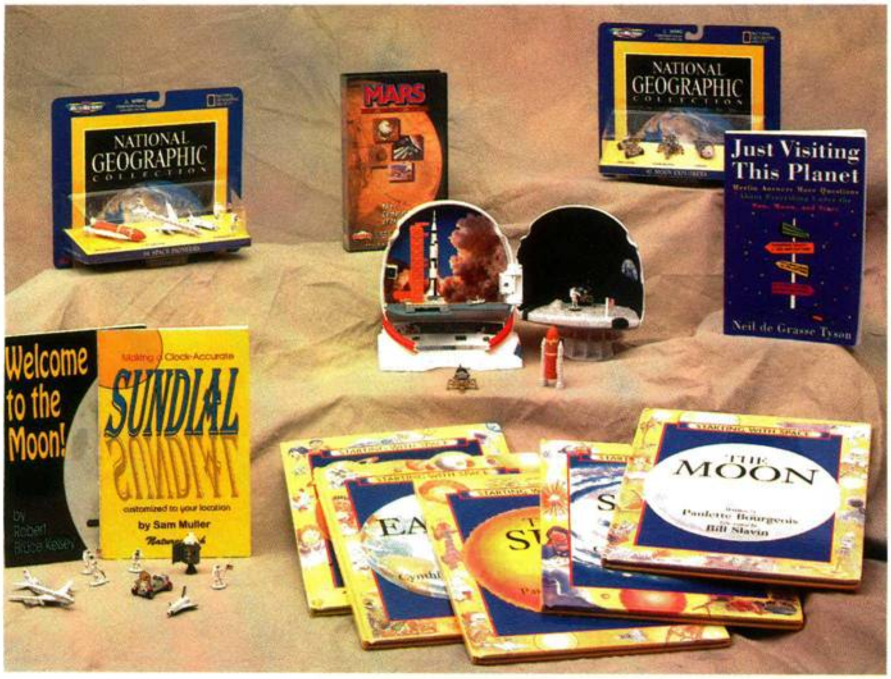
The video reaches back into the past and stretches forward into the future — the history of past Mars missions is provided, as well as the plans for missions yet to come. A great deal of science is provided as well. Watching this hour-long video will leave you and your children with a remarkable understanding of Mars's geology, meteorology, history, and future as well as a glimpse at the technology and advances we as earthlings have employed in order to learn all that we now know. Finley-Holiday has additional videos for sale, including several on the Apollo moon mission, the history of the Space Shuttle, the Kennedy Space Center, and natural processes on Earth such as earthquakes, volcanoes, and geysers.

Wrapping It Up

Now that you know what's out there, all that's left to do is charge it and wrap it up. Most of the products I've included can be found in your local toy store or book store, but if you're having trouble tracking something down, consult "The Details" information on contacting manufacturers or distributors directly. And whether you choose fancy wrapping paper or the funnies to conceal your gifts is up to you — just please don't use the pages of *Astronomy*. ■

Jeanette Brown. former copy editor of Astronomy, *is currently working toward a graduate degree at New York University.*

Astronomical toys, games, videos, and books will delight and educate your children.



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MAGNITUDE

Graduate to a better understanding of how to measure a star's brightness.

by Bob Berman

To the ancient Greeks the sky was a smorgasbord of abstract patterns. The nature and origin of the stars puzzled observers, and few constellations resembled the mythological figures they were supposed to portray. A nocturnal stroll was essentially an excursion through a disorienting madhouse.

But the Greeks, gifted essay-test-takers who could fill in the blanks as well as any culture before or since, devised a plan for sorting the stars. The astronomer Hipparchus proposed grouping stars by their brightness. He assigned every star one of six different magnitudes. The very brightest stars received a 1 and the very dimmest, a 6. Invented 2,200 years ago, Hipparchus's system is still in use today.

Unfortunately, as the entertaining Trojan Horse incident taught the world, we should sometimes beware of Greeks bearing gifts: Hipparchus's magnitude system was a counterintuitive, reverse-order scheme that still plagues beginning astronomers. If he had been a food critic, he would have awarded the worst dinner six stars and the finest cuisine only one. And his system was crude. Luminaries such as Sirius and Betelgeuse were referred to as 1st-magnitude stars even though their brightnesses differed noticeably. Centuries lumbered by and no one seemed to mind.

It took William Herschel, who had already blown everyone's mind by finding the first-ever new planet (Uranus, in 1781) to suggest a way to accurately measure brightness, and Norman Pogson, in the middle of the 19th century, to spell it out. Both had observed that the eye doesn't notice intervals of brightness as much as it notices ratios. For example, if someone replaced a 50-watt bulb with a 60-watt one, you probably wouldn't discern the 10-watt increment change. But if they replaced the 50-watt bulb with a 100-watt bulb, doubling the brightness, you would notice

The crescent moon and Venus hang in the spring sky over Quebec, Canada. The crescent moon shines at magnitude –9. Venus has a magnitude of –4, the point at which objects cast shadows in very dark areas.

George Livadaras

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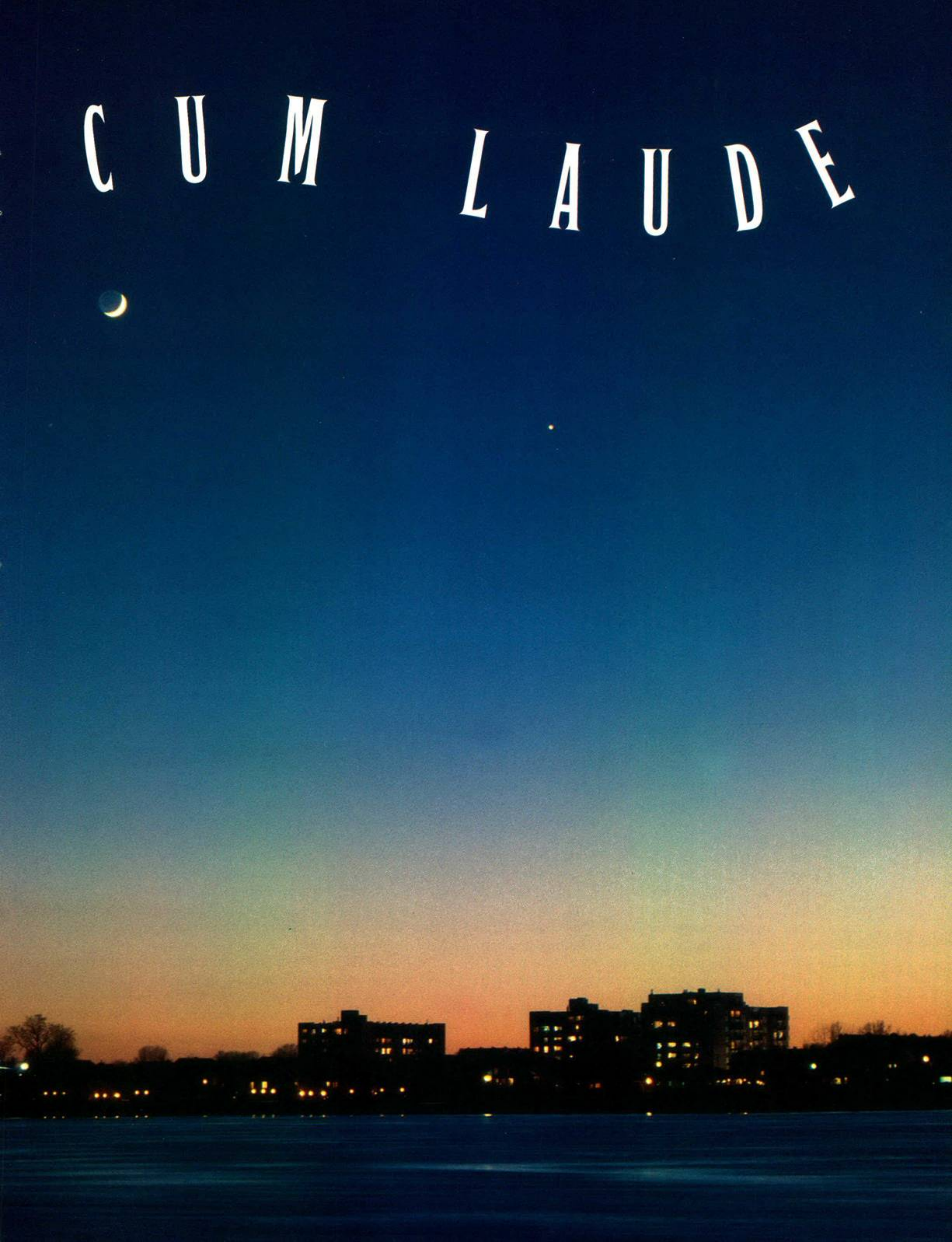

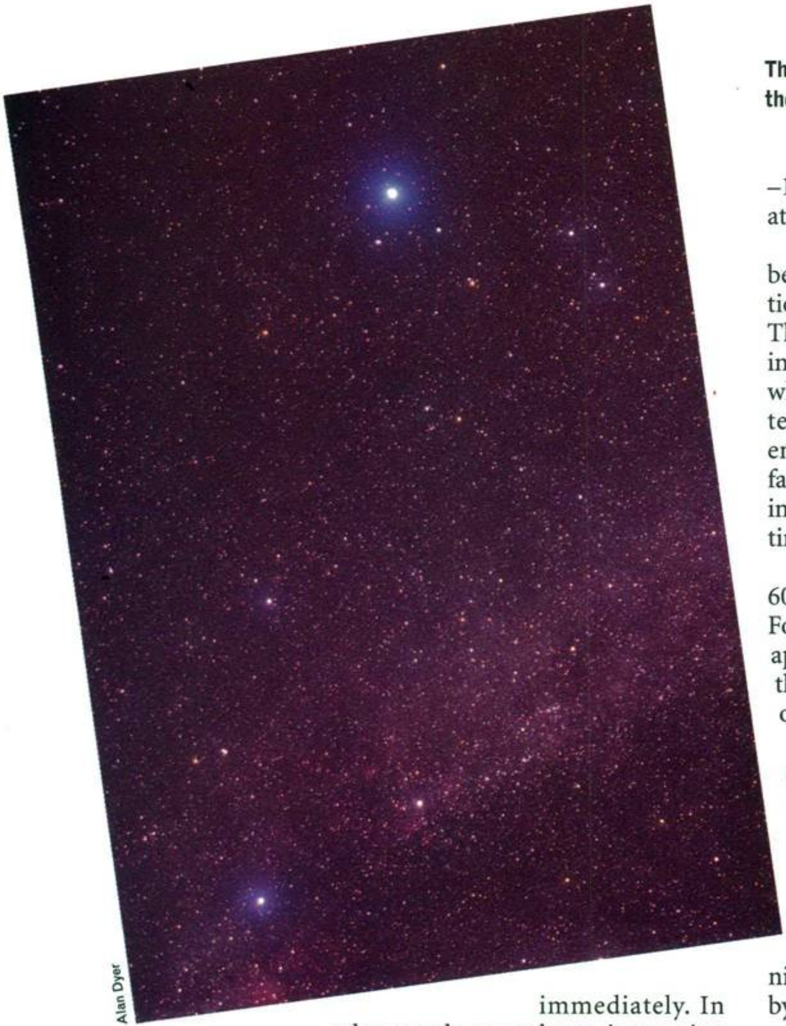

The brightest of the summer stars, Vega, glows at magnitude 0.04. At the bottom left corner of the image, 1st-magnitude Deneb shines.

Alan Dyer

immediately. In other words, to make an impression on our sense organs, we've got to be whacked with a dramatic difference.

When Herschel and Pogson looked at the heavens, they calculated that a classic 1st-magnitude star, such as Deneb, is 100 times brighter than a 6th-magnitude star, about the faintest you can see on a moonless night with the naked eye. Pogson determined that a five-magnitude jump equalled a hundred-fold brightness change, and defined each magnitude as the fifth root of 100, or 2.512. Voilá. Each magnitude is 2.5 times brighter than the next higher number.

Easy enough. Astronomers now use photometers, charge-coupled devices (CCDs), and other electronic methods to accurately measure light. We still express it in the old, cuckoo upside-down way Hipparchus did. Yet, the only real change is that modern magnitudes have burst through the Greek's ceiling of one. More accurate reckoning has promoted a half dozen stars all the way up to zero and beyond.

You can observe two zero-magnitude stars this month in the early evening by checking out creamy Capella high in the northeast and red Betelguese in the east. Later in the evening, the Dog Star, Sirius blazes in the southwest at magnitude –1.5. If you want something really bright, say around magnitude –4, wait until mid-December for Venus to rise in the west after sunset.

By chance, the brightness of that nearest planet turns out to be instructive: Magnitude –4 is the point at which objects cast shadows. You must be away from artificial lights, though. Once, on a remote South Pacific island, I saw my shadow cast in the sand by the light of Venus.

If the full moon is out, you're looking at magnitude –12.6. Then, when the sun rises, you're gazing (not too long) at an object of –26.5. Only a nuclear blast is brighter.

But it's in the opposite direction, in the murky depths below 6th magnitude, to which astronomers turn their affections. This is where many discoveries have yet to be made. This realm, beyond the naked-eye barrier, was first explored in 1609 when Galileo aimed a scope skyward. He discovered what too many modern beginners have yet to learn — that telescopes are brightness-enhancing devices more than enlarging devices. They typically enhance an object by a factor of a thousand — and only then is the now-brightened image magnified, usually by no more than a couple hundred times.

By focusing extra light into your pupil, even a small 60mm telescope takes you to the 12th magnitude. Imagine: For $50 at any department store you can increase every star's apparent luminosity a few hundred times. Compared with the naked eye, you've gained five or six magnitudes at a cost of just eight bucks per magnitude.

As telescopes get bigger, the cost-per-magnitude climbs dramatically. A 24-inch telescope costing $20,000 will brighten things by just 1.5 magnitudes over a 12-inch scope that costs $2,000. By the time you get to the Palomar or Keck class, you're in over your head to the tune of millions of dollars per magnitude. Brightness isn't cheap.

So the low-end is where you find the bargains. An ordinary pair of binoculars dives you down to 9th magnitude, where nine times more stars appear than can be seen by the naked eye.

Now, if there were just as many stars and galaxies at any one magnitude as at the next, astronomers wouldn't be so obsessed with plunging ever-deeper into the muddy Land of the Obscure. But even a quick skyward glance reveals a basic celestial fact: There are more medium-bright stars than dazzling ones, and far more dim stars than mediums — no different from any assortment of people. Galileo found that this hierarchy continues with a vengeance below the sixth magnitude naked-eye threshold; his little two-inch telescope managed to show 50,000 stars instead of the mere 6,000 seen by the eye alone.

Through a 5-meter telescope such as the Hale Telescope at Palomar, the visual limit extends to the 21th magnitude, while its photographs show objects as faint as 25th. This is faint indeed; below the 18th magnitude, a murky realm of hundreds of millions of stars awaits, whose properties have not even been cataloged.

Recently, CCDs attached to the largest new telescopes have reached magnitude 28.5, while in 1996 an extraordinary 100-hour exposure through the Hubble Space Telescope, the so-called Hubble Deep Field, picked up faint stars and galaxies of the 30th magnitude.

The 30th magnitude is hard to imagine. Such an object is a trillion times dimmer than Deneb. Its light is equal to the glow of a single cigarette as seen from the moon. And such amazing dimness brings up the question of where an ultimate limit may lie — because in order to detect a faint object it has to be brighter than the sky itself. The background heavens, from an ideally dark site, emit a feeble glow equal to a 10th magnitude star smeared over each moon-sized piece of sky. Most of this natural night sky illumination is "airglow" caused by the sun's ultraviolet energy exciting atmospheric gases. Hubble or any future orbiting telescopes dispense with airglow.

The North Star or those of Orion's belt, at 2nd magnitude, sit about halfway between the magnitude extremes of the sun and the faintest stars detectable today. So we could appreciate technology's amazing ability to capture incredibly faint images by picturing how much brighter the sun appears than Polaris, and envisioning that same luminosity jump downward.

In truth, such an exercise is futile. We cannot imagine the 25 to 30 magnitude difference between the sun and the night's stars because we can never see them side by side. Photochemical changes in the retina, as if the "ISO film speed" of the eye has been fantastically boosted, coupled with the pupil's dilation, hugely alter our response to faint light. That's why, if you ask people how much brighter the sun appears than the full moon, most would guess that there's something like a 50-fold or 100-fold difference. Nobody comes up with the correct answer: The sun is 450,000 times more brilliant!

It is this inability of the eye to gauge brightness accurately that makes "standards" so important. Originally, Pogson suggested that the stars Aldebaran and Altair define 1st magnitude. Later, Polaris was used as the sky's platinum bar — it defined magnitude two. Then the North Star was found to suffer a small but unfortunate variability of a tenth of a magnitude, disqualifying it as a brightness archetype — and the search for something more reliable took place.

Now professional astronomers use a whole sequence of stars spread throughout the heavens to milestone brightness variety and allow comparisons for variable star studies. You can observe your own sequence by looking into the Little Dipper's skimpy bowl. Its brightest star, Kochab, burns at magnitude two, nearly matching Polaris. The next bowl star, Gamma, shines at magnitude three, while the two others gleam at magnitudes four and five. Jump from one star to the next to see for yourself what a two-and-a-half-fold brightness change looks like.

Orion rises on its side over California. The three stars in the warrior's belt shine at magnitude 2. Betelguese marks Orion's right shoulder and glows at magnitude 1.

Jerry Schad

Alan Dyer

The Big Dipper lies just over the horizon. Follow the two pointer stars, Merak and Dubhe, to Polaris, a 2nd-magnitude star. It marks the end of the Little Dipper's handle, which curves down and to the left from Polaris, smack dab into Kochab, a 2nd-magnitude star.

While you're observing, imagine what the sky would be like if all of the stars were positioned at the same distance, allowing us a true picture of stellar luminosity. Astronomers play this pretend game routinely, by imagining everything at 10 parsecs (32.6 light-years) and expressing the result as absolute magnitude. If the sun were pushed back that far, it would appear a nearly invisible magnitude five, matching the faintest star of the Little Dipper's bowl. In fact, dim is par for the cosmic course. For every star you see in the sky, a hundred other ruddy unseen ones lie sprinkled throughout the firmament. The 2,500 naked-eye stars visible at nightfall may hearten poets and lovers, but they're not representative of the universe. They are the luminous elite, the sky's movie stars. We gaze up at a false sample and get an unrealistic sense of dazzle.

But so what? This exaggerated stellar gaiety, added to the eye-catching lack of uniformity, makes the heavens interesting and beautiful — and intriguing enough to have inspired humans toward their first logical system for classifying and measuring the universe. Star light, star bright — the fascination never ends. ■

Bob Berman is a frequent contributer to Astronomy *and host of National Public Radio's* Skywindow Show. *His newest book,* Cosmic Adventure, *was published in November 1998 by William Morrow.*

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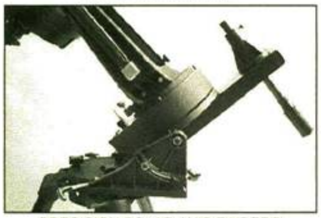
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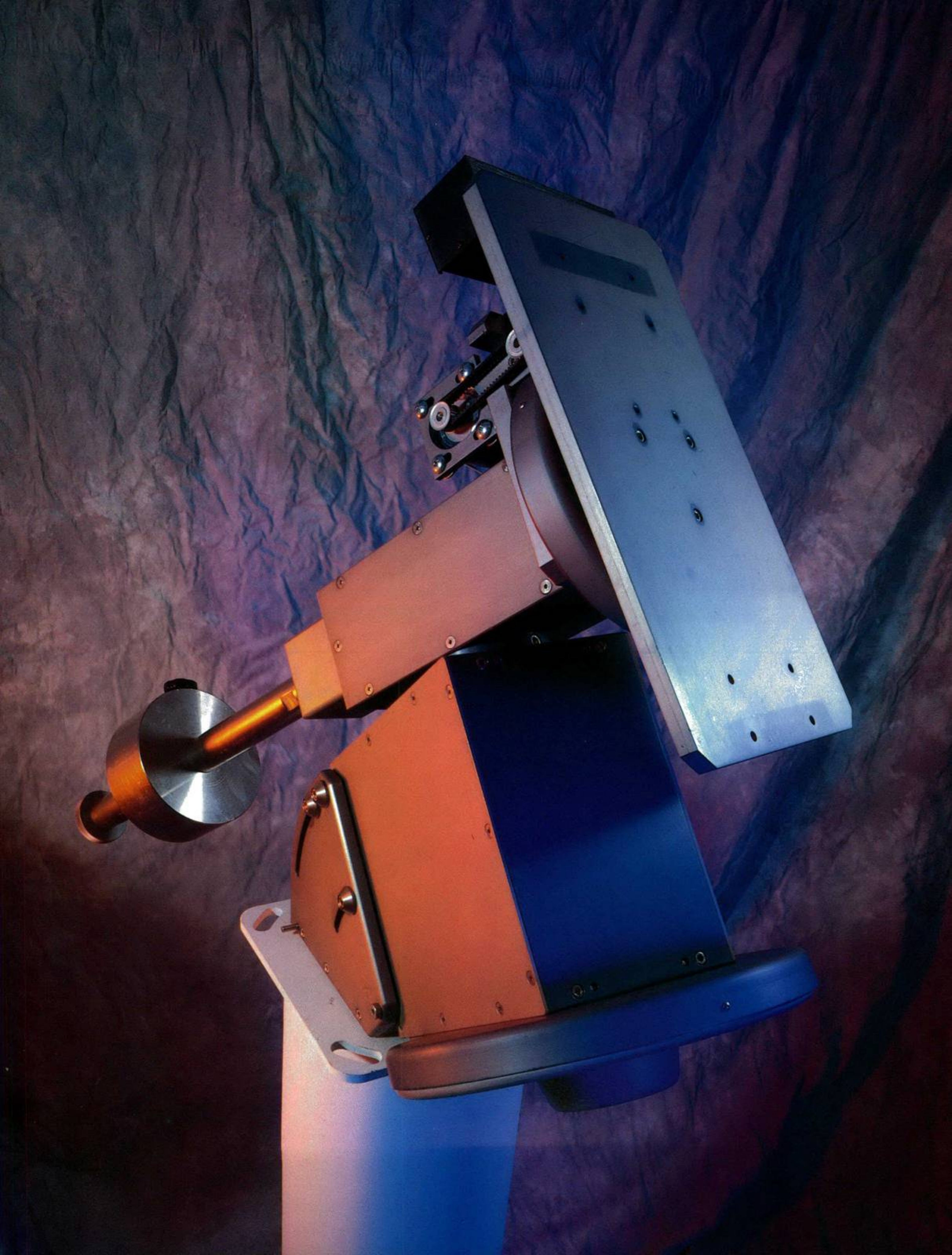


Standing STEADY

Software Bisque's new telescope mount combines state of the art automation with rock-solid stability.

text by Gregory Terrance and photos by William Zuback

A telescope is only as good as the mount that holds it. That statement may surprise some, but most experienced observers will agree. You cannot have an enjoyable, frustration-free time viewing the night sky with a telescope if it rests on a jittery mount.

My first telescope was held by just such a mount. It had outstanding optics that were great for observing the moon and planets. Unfortunately, the tube assembly was more impressive than the mount — a fork-mount that shook every time I touched the focuser. To make matters worse, the mount's poor drive system completely frustrated my initial attempts at taking guided deep-sky astrophotos.

To get the most from a telescope, it has to be matched with a solid mount, one suited to your specific astronomical needs. Visual astronomers can get away with simple, but sturdy, alt-azimuth mounts like the Dobsonian. An astroimager, on the other hand, needs an equatorial mount — preferably one with a quality drive system.

Software Bisque's Paramount GT-1100 robotic mount is a solid telescope platform endowed with a superb drive system. Consider it a "new-age" German equatorial mount that is tailor-made for advanced astro-imaging. The Paramount comes with software that, among other things, allows it to be controlled from the cozy comfort of your den or home office. The telescope can also be accessed and controlled through the Internet. The mount and software are an impressive combination. There are enough advanced features to satisfy the most voracious imager well into the next millennium.

The Paramount GT-1100 makes home-dome automation a reality. This professional-quality mount offers amateurs the capability to remotely access the telescope and CCD camera, while combining stability with precision pointing accuracy.

HARDWARE DESCRIPTION

The GT-1100 combines high-quality components with top-notch machining. It is capable of professional levels of pointing accuracy (better than one arcminute across the entire sky) and has variable slew rates of up to 2° per second. Fully assembled, the mount (right ascension housing, declination housing, and declination shaft) weighs slightly more than 100 pounds and can effortlessly carry a telescope in the 75-pound range. It is supplied with a six-button, multi-functional hand controller and two nickel-plated counter weights totaling 50 pounds.

A solid 1.5-inch stainless-steel shaft is used for both the declination and right ascension axis. The right ascension axis uses a precision, research-grade Edward Byers 11.5-inch gear with a tracking accuracy of five arcseconds or better — this is before the Paramount's permanent periodic error correction is applied. A 7.5-inch Byers gear is used for declination control. Both are driven by stainless-steel worm gears with 60-ounce-per-inch stepper motors. All of the drive components (motors, worm gears, and drive gears) are protected with aluminum covers.

The Paramount can be pointed by a computer or with the supplied hand controller. Mechanical slow motion controls and clutches are not used since *TPoint* (see "Professional Astronomy Software Suite" p. 101) requires the gear-to-worm synchronization of both axes be maintained. These operating restrictions mean the mount cannot be pointed manually.

The polar alignment accuracy and right ascension gear quality of a telescope system ultimately determine how long an unguided exposure can be before star trails become noticeable. To simplify polar alignment, the Paramount is equipped with precision 80-pitch altitude and azimuth adjustment screws. Both screws have a known effect on the mount's movement: five arcminutes per rotation and six

Paramount's research-grade 11.5-inch Byers gear keeps your scope's right ascension tracking to within five arcseconds or better.

arcminutes per rotation, respectively. These calibrated fine adjustments make the polar alignment process much easier, user friendly, and predictable.

As an aid for remote operations, the GT-1100 uses an internal 168-pin ribbon cable to route all camera, telescope, and miscellaneous inputs through the mount. This eliminates the chance of getting cables snagged or caught during an imaging session. Inputs are plugged directly into the instrument panel (located below the mounting plate) and routed to the base panel where they are reconnected to the correct device. With the Paramount's internal cabling, a completely outfitted telescope with an electric focuser, dew heater, and CCD camera, can be used without any cables drooping to the observatory floor.

PARAMOUNT SOFTWARE

The Paramount is supplied with a Professional Astronomy Software Suite (PASS) — a personal computer running *Windows 95* or *Windows NT* is required. Included in the group are *The Sky*, *CCDsoft*, *TPoint*, and *Orchestrate*. With these programs and a GT-1100 mount, an astronomer can take complete control over the imaging system (telescope, mount, and CCD camera) for unattended, robotic operations. With PASS it's possible to take hundreds of CCD images in one night without ever leaving the computer or touching the telescope. The cost of such technology is a steeper-than-normal learning curve. Fortunately, you do not have to understand all of the software features to get started.

USING THE PARAMOUNT

The Paramount was installed on a permanent pier in my backyard. I put it through its paces during winter conditions that were heavily influenced by El Niño. Protected against the weather by only a plastic tarpaulin, the mount never showed any signs of stress or malfunction. In fact, the only problem was a loose right ascension nut that slightly affected the mount's pointing accuracy. That was easily remedied by removing the right ascension cover and tightening the nut. The Paramount withstood winter's rain, snow, and sub-zero temperatures well. Here is a synopsis:

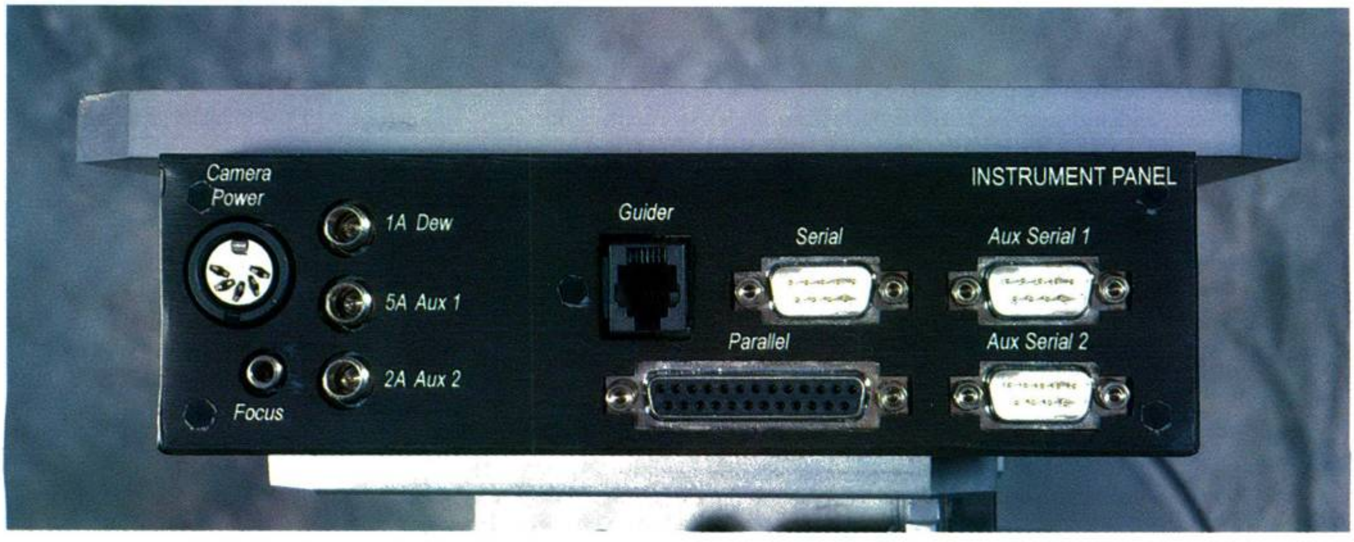
STABILITY

Basic "tap-tests" were performed to determine its damping capabilities. Using an eyepiece that yielded a 95x magnification, a sharp rap with my knuckles on the telescope's focuser took between one and one-and-a-half seconds to stabilize. Some of the vibrations were caused by the telescope's tube, which was made from thin aluminum.

POINTING ACCURACY

Many Go-To mounts boast impressive pointing capabilities — but only if they are recalibrated to a nearby star each time the mount is aimed to a new region. The Paramount avoids the hassle of such re-synchronization. Instead it relies on its software, drive

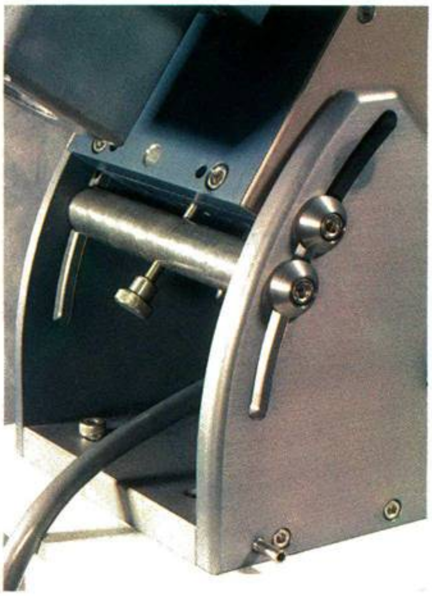
Additions like a CCD camera, video camera, and dew heater can all be accomodated by the Paramount's instrument panel.



system, and polar alignment capabilities. In initial tests, the mount constantly placed objects within two to five arcminutes of the field's center. That's not bad, considering I did not have perfect polar alignment. I was able to lower these figures by improving the mount's polar alignment and employing the error-correcting abilities of *TPoint*. After some fine-tuning, the telescope's pointing accuracy improved to better than two arcminutes. Impressive. Then *The Sky* was used to point the telescope at a dozen different deep-sky objects; 30-second CCD images showed the galaxy or nebula dead center each time.

DRIVE ACCURACY

Since the Paramount was built around the concept of imaging productivity and robotic operation, it had to have a superior right ascension gear system. Otherwise, tracking errors would ruin unguided images. Did it deliver? You bet. The Byers right ascension drive claims a periodic error of five arcseconds or better. My tests showed this to be true.



Make your rough polar alignments with the right ascension housing nuts (two on each side of the wedge) and the two shoulder bolts at the base of the wedge. Fine adjustments are made with the altitude adjustment screw (center of the bar) and the azimuth knobs that extend from both sides of the wedge at its base (bottom-center of photograph).

SLEWING

The Paramount has a maximum slew rate of 2° per second, which is slower than other systems that I've encountered. Even so, most objects were located and centered in less than 60 seconds. For instance, I used the stars in Orion for my first mapping session; the Paramount took about 19 seconds to travel from Betelgeuse to Rigel. The longest slew times (more than 150 seconds from Bellatrix to Sirius) resulted when the mount had to "flip" itself to reach objects on the other side of the meridian. Noise levels for all slew

PROFESSIONAL ASTRONOMY SOFTWARE SUITE

What follows is a brief description of the software included with the Paramount system's package.

The Sky (Level IV)

The Sky is a planetarium-style computer program that places the cosmos at your fingertips. Use it to view the night sky at any time or date, and from any location. It includes an astronomy tutorial, solar system viewer, conjunction finder, star-chart maker, object database, and much more. *The Sky* is the main program in the suite and is used to set up and control the Paramount.

One example of how the program interfaces with the Paramount is its "park" feature. The park command sends a series of instructions to move the Paramount to a park position. Subsequent imaging sessions can be auto-started without any alignment procedure – a great feature for remote, unattended imaging.

CCDsoft

This program is an image-acquisition and image-processing package. It has all of the tools needed to acquire and process CCD images. It also includes a tutorial for beginners. Many other features – like tri-color assembly, auto-guiding, registering multiple planetary images, photometry, and more – are easily accessible. *CCDsoft* is a definite step up from the software normally included with most CCD cameras.

Orchestrate

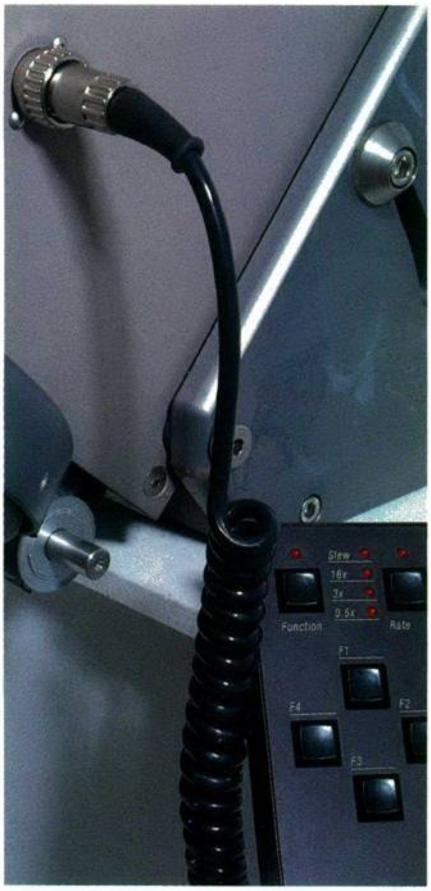
A software "scripting" tool used to set up and run automated imaging sessions, *Orchestrate* controls *The Sky*, *CCDsoft*, and the Paramount. It enables the mount to find an object, then tells the camera to take an image. Once the exposure is complete, *Orchestrate* uses *The Sky* to slew the mount to the the next object. Because image selection can be preprogrammed, the telescope and CCD camera operate without delay. This makes *Orchestrate* a wonderful tool for maximizing imaging sessions, and it's all accomplished whether the GT-1100 is in your backyard or in another state.

TPoint

All telescope systems suffer from pointing inaccuracies due to polar misalignment and mechanical errors. *TPoint* is an error-modeling program that can compensate for errors and dramatically improve a system's pointing capabilities.

The program works through a process called mapping (locating and centering a known star, and instructing *The Sky* to "map" the object). After mapping a minimum of six stars, *TPoint* can determine the magnitude and type of errors in a telescope's system. The software corrects for repeatable system errors. Random changes, like mirror-flop, cannot be taken into account.

TPoint also helps the telescope attain optimum polar alignment. I had a lot of fun with this feature – its ability to reveal a mount's deviation from true celestial north was fascinating. Polar misalignment figures, in altitude and azimuth, were reported in arcsecond increments. For example, I initially polar aligned the Paramount using the star-drift method. My first mapping session indicated I was 650 arcseconds above and 250 arcseconds east of the North Celestial Pole. These values dropped as I adjusted and improved Paramount's polar alignment. *TPoint* reduced the time required to fine-tune a mount (compared to traditional methods), but its real value was the ability to provide quantitative feedback and deadly accurate results.


Slew
16x
3x
0.5x
Function
Rate
F1
F4
F2
F3

speeds were kept to a minimum. Even with a three-pound CCD camera attached, the drive motors never sounded strained and the gear system did not exhibit any chatter.

With all of its hardware and software capabilities, the Paramount can be considered an ultimate imaging machine. Compared to the high quality German equatorial mounts that I've used for the last decade, it almost makes CCD imaging easy. Certainly, in these days of $400 eyepieces and $6,500 CCD cameras, the Paramount rates as something of a bargain at $9,500. Although the cost will place it out of reach for many individual astronomers, it is a reasonable investment for small colleges, astronomy clubs, or a group of enthusiastic astro-imagers. Not only does the price of admission get you a complete telescope mount, with nearly unlimited imaging capabilities, it also buys a suite of software that covers every imaging need from Acquire to Zoom. ◼

Gregory Terrance is an astro-imager living in New York. Visit his website at http://www.frontiernet.net/~gregoryt/.

You can control the Paramount with the six-button, multi-function hand controller (top) or the complete *Professional Astronomy Software Suite* (below).

CCDSOFT
CCD Astronomy Software
Manual
TPOINT
Telescope Pointing Analysis Software
Manual
TheSky
Astronomy Software
Manual
VERSION 4
TheSky Family of Astronomical Products
Paramount GT-1100
CCD Cameras
Software Bisque
Astronomy Software and Hardware Catalog

SPECIFICATIONS

Hardware

Weight: 45 kg (100 lb) without optical tube assembly or counterweights

34 kg (75 lb.) instrument capacity

1-inch stainless steel right ascension and declination shafts

11.5-inch Byers research-grade right ascension gears; 7-inch Byers declination gears

Calibrated 80-pitch thread altitude and azimuth adjustment screws

22.7 kg (50 lb.) counterweights

Clutchless operation

Control System

Six-button, multi-function hand controller with 12-foot cable

Internal wiring for mount control, parallel or serial port, CCD camera control, and two additional devices

TCE-1 Motion Control System from Santa Barbara Instrument Group

Auto-guider input port

60 inch-ounce stepper-motor control on both axes

Variable slew rates up to 2° per second

Permanent periodic error correction

Simultaneously control both a parallel port camera (ST-7, ST-8, TC-255) and the mount with a single parallel port

Auto start capability

Visit Software Bisque's website at http://www.bisque.com for more details.

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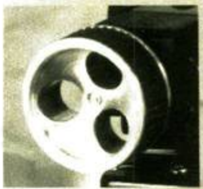

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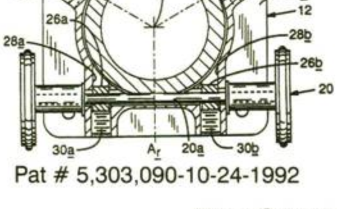
SO WHAT'S THE BIG DEAL ABOUT FOCUS TUBE TRAVEL?

Aren't all focusers the same? Definitely not!

When it comes to the rate of focus tube travel, slower is better. When it comes to achieving the ultimate sharply focused image, the more "mechanical advantage" you have, the more perfect focus you will be able to achieve.

Imagine a helmsman trying to set the course of his ship with a 4" steering wheel as opposed to a 36" wheel. It is obvious that you achieve much better control with the larger steering wheel.

The same is true with focusing. Most rack-and-pinion focusers move the focus tube 1" with one revolution of the knob. All of JMI NGF-focusers have, in the past, moved the focusing tube .58" per revolution.



Pat # 5,303,090-10-24-1992

JMI's motto: Strive constantly to surpass yourself not the competition.

It is time to once again surpass ourselves.

Introducing the 1998 line of focusers from JMI. The NGF-Dx2 delivers .39" travel per revolution. *The NGF-Dx1 has two speeds. The fast knob delivers .39" per revolution and the micro fine knob, delivers an incredible .075" per revolution that translates to more than 13-times finer action than most rack-and-pinion focusers.

Secondly...

We now also have an enclosed frame which is stronger than before. We went back the drawing board and back to one of our original patents -a totally enclosed one-piece Crayford focuser with captivated bearings.

All JMI focusers are still free of image shift. They are still gearless and pressure driven, and they still provide the ultimate focus.

Zero Image Shift Focuser

"To put it bluntly, if there's a better line of commercial focusers made for imaging, I don't know about it." Dennis di Cicco - 3/94 Sky & Telescope

- Summer 1991, JMI develops the first zero-image shift focuser
- Summer 1992, JMI develops the first NGF-S (for SCTs)
- October 1992, JMI patents first one-piece Crayford focuser.
- Spring 1993, JMI offers the first low-cost NGF focusers
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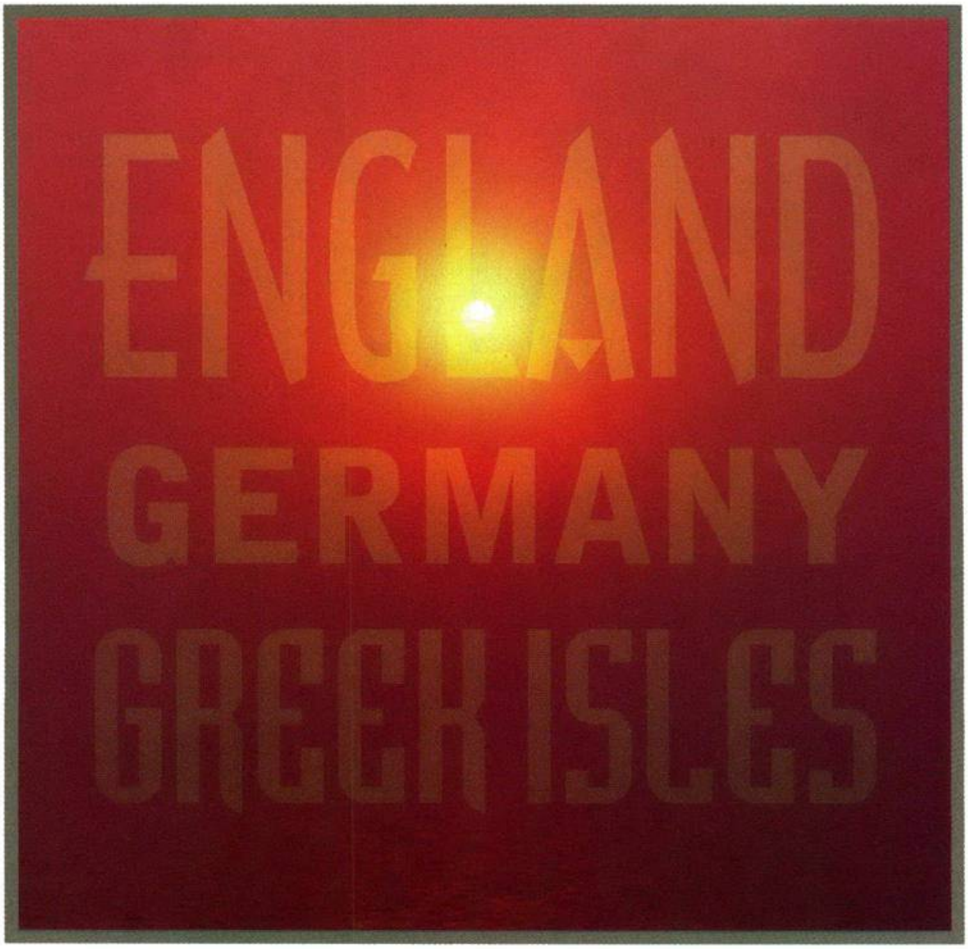
Astronomy Magazine presents

1999 solar eclipse tours



Come join ***Astronomy*** Magazine on one of its four amazing solar eclipse tours being held August 6-15, 1999. Along with catching one of the most spectacular views of the last solar eclipse of the 20th century, you will experience the magnificent sights and sounds of such wonderful places as England, Germany, and the Greek Isles in the process. Choose your favorite destination today.

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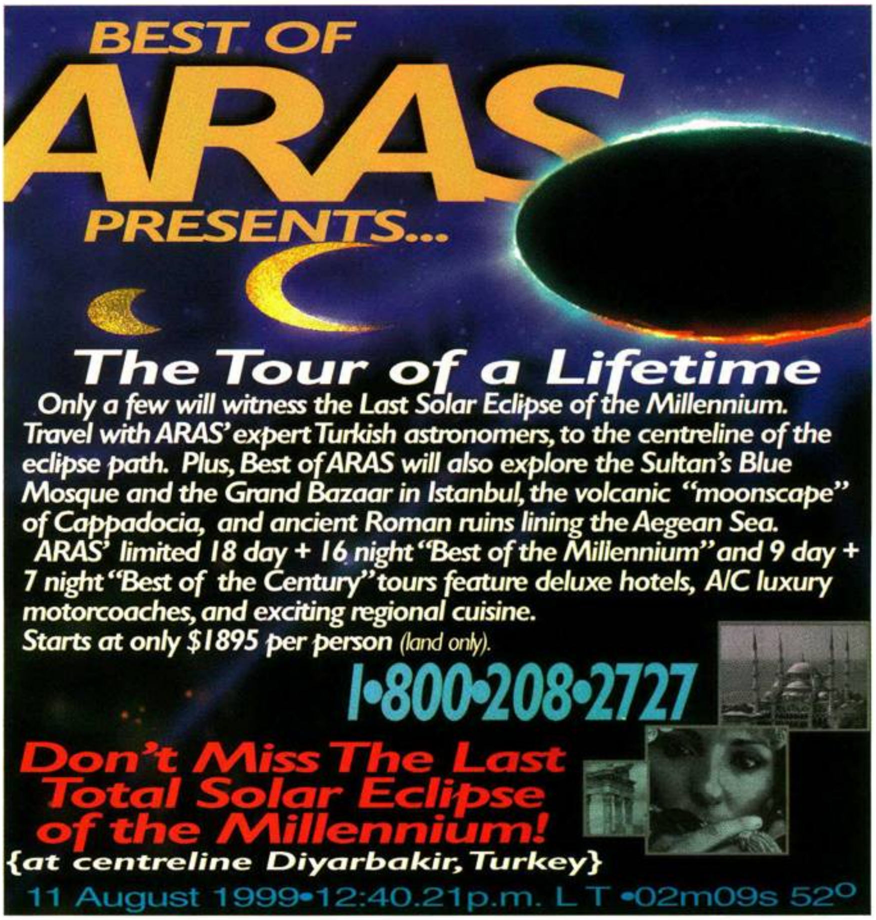

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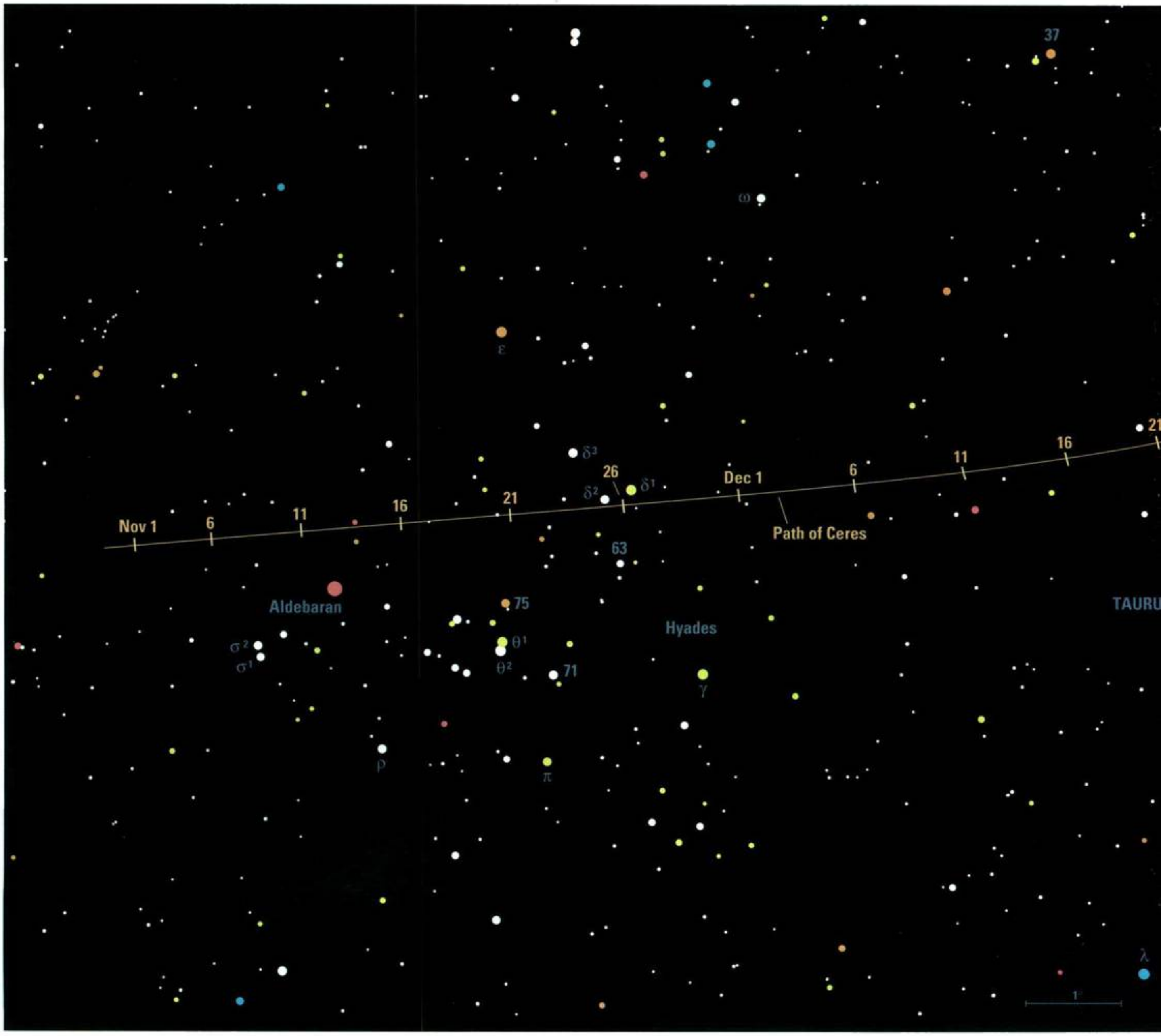
Ceres Pierces the Hy

Grab a small scope and head out for a glorious view of the solar system's largest asteroid.

by Richard Talcott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Astronomy: Elisabeth Rowan

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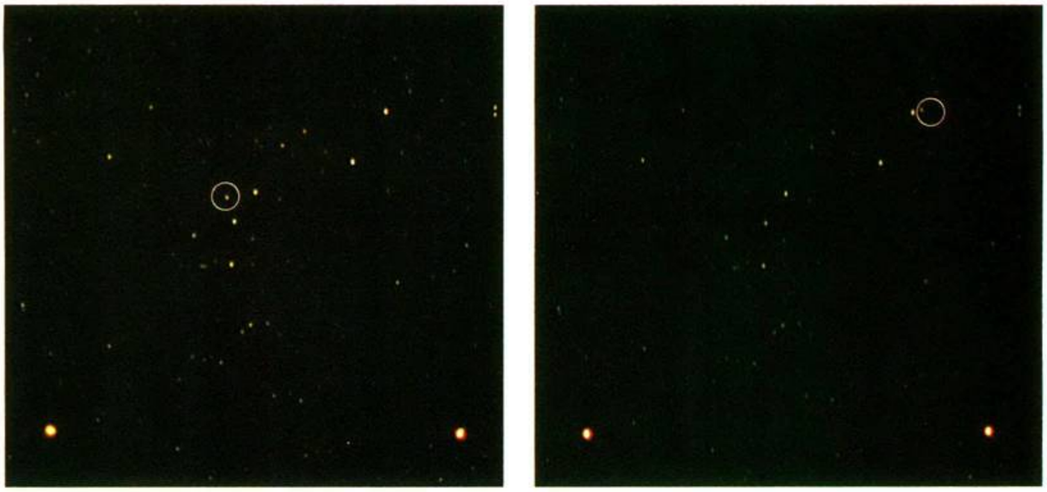
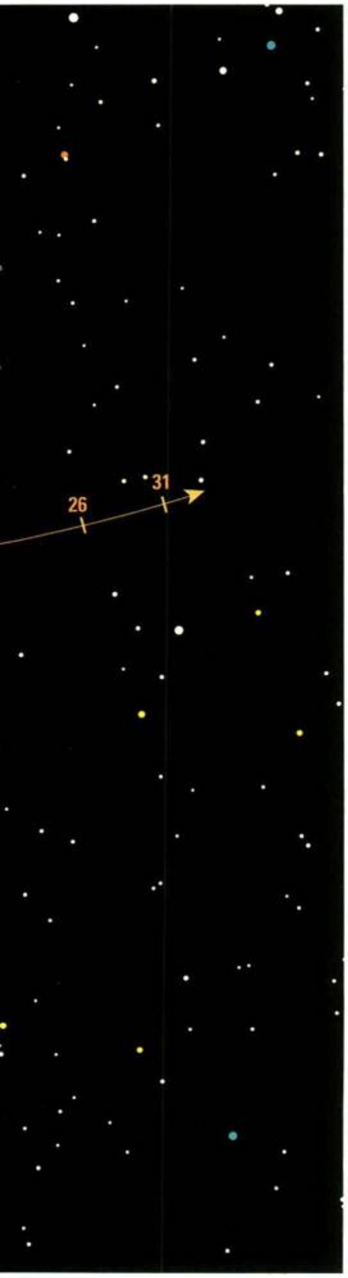

Kevin Bolam



On the first day of the 19th century, Sicilian astronomer Giuseppe Piazzi spotted an "intruder" among the stars of the constellation Taurus. When he came back to observe the same object on succeeding nights, he noticed that it had moved slightly — a sure sign that this was a previously unknown member of the solar system. At first Piazzi thought he had discovered a comet, but what he really had laid his eyes on was an asteroid, the initial member of a vast collection of similar objects that orbit the sun mainly between Mars and Jupiter. He named the object Ceres after the Roman goddess of agriculture and the protecting goddess of Sicily.

Now, as the 20th century winds down, Ceres returns to its old haunts. During the final two months of 1998, the asteroid makes a beeline across Taurus the Bull, spending much of this time among the background stars of the Hyades star cluster. This distinct V-shaped pattern, which marks the face of the bull, provides a glorious backdrop for observing the large, bright asteroid.

To locate Taurus and the Hyades, head out during midevening and look low in the east. There you should see the prominent winter constellation Orion the Hunter, highlighted by two brilliant stars — reddish Betelgeuse at one corner and bluish Rigel at the opposite corner — and in between three medium-bright stars in a short row representing the hunter's belt. Continue the line formed by this trio up away from the horizon and you'll come to the orangish 1st-magnitude star Aldebaran, which lies at one end of the Hyades' V and marks the eye of Taurus. (The circular star map located at the center of this magazine can help you find Taurus.) Then simply use the map at left to zero in on Ceres.

To see Ceres, you'll need at least some optical aid. Glowing at 7th magnitude, it is just a bit too faint to glimpse with the naked eye. Binoculars bring it easily into view — and reveal the Hyades in all its glory as well — but you'll be best able to identify it with a small telescope operating at low power.

Ceres reaches opposition on November 28, when it lies opposite the sun in the sky and remains visible all night. The few weeks surrounding opposition are typically the best times to view a solar system object because it is then closest to Earth and shining at its brightest. With Ceres this year, the passage through the Hyades only adds to the spectacle.

Pay particular attention around mid-November, when the asteroid passes less than 1° north of Aldebaran. (Despite its proximity to the Hyades in the sky, Aldebaran is not a true cluster member and actually lies about half as far away.) Another pretty conjunction follows at the end of the month, when Ceres skims a scant 0.1° south of Delta^1 (δ^1) and Delta^2 (δ^2) Tauri.

The map shows stars down to magnitude 9.0, so you should have little problem distinguishing Ceres from the background stars. But if you want to confirm your sighting, it's worth returning to the area a night or two later and witnessing for yourself the change in position caused by the asteroid's and Earth's orbital motions. Maybe then you can feel some of what Piazzi did that momentous night nearly 200 years ago. ■

Left: Backyard observers have a treat in store during the waning days of November and early December when Ceres, the largest and second brightest asteroid, slices through the brilliant and colorful star cluster known as the Hyades.

Top: One surefire way to confirm a sighting of Ceres is to watch for its motion against the background stars over the course of a few days. These photos show a week's worth of movement of the asteroid (circled) through western Gemini during November 1989.

Meade & Celestron
LUMICON carries a full line of telescopes and accessories. Fast Delivery, Competitive Prices.

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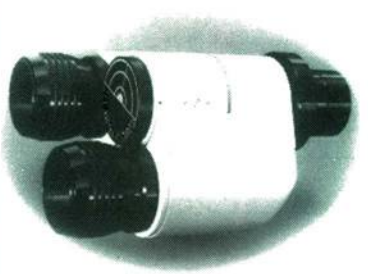


NEW LUMICON BINOCULAR VIEWER $649*

*INTRODUCTORY PRICE

The New LUMICON Binocular Viewer is judged to be equal or superior to even more expensive binoviewers. Made for LUMICON by a Zeiss subcontractor, these exquisite German-made units have the highest image transmission (91%). Threaded for filters. **$649***. Both planetary and deep-sky viewers will be impressed.

Introductory price; $699 after Jan. 31, 1999

TELE VUE™

NEW! Bino Vue Binocular Viewer

5X! Powermate boosts magnification 5X	$179
Ranger 70mm f/6.8 apochromat w/45° diag.	$659
Pronto 70mm f/6.8 w/45° erecting prism	$889
NEW! Bino Vue binocular viewer	$899
Gibraltar mount with ash wood tripod	$535
8, 11, 15mm Plossl . **$95**, 20, 25mm	$105
32mm Plossl, widest true field in 1¼"	$125
55mm 2" Plossl, widest possible field	$235
2.0x or 3.0x Tele Vue Barlow Lens	$119
2" Giant Barlow - 2x	$185
4.8mm Nagler, 82° field, 1¼" eyepiece	$175
7mm Nagler, 1¼" eyepiece, 82° field	$225
9mm Nagler, 82° field, 1¼" or 2"	$245
13mm Nagler, 82° field, 1¼" or 2"	$315
12mm Nagler, Type II, 82°, 1¼"/2"	$295
16mm Nagler, Type II, 82°, 1¼"/2"	$315
20mm Nagler, Type II, 82°, 2" only	$395
2" Paracorr Visual Coma Corrector	$259
15mm Panoptic 1¼", 68° field	$215
19mm Panoptic 1¼", 68° field	$245
22mm Panoptic 1¼"/2", 68°	$285
27mm Panoptic 2", 68° field	$335
35mm Panoptic 2", 68° field	$365

TeleVue Warranty may not be valid outside USA.

NEW! ENHANCED ALUMINUM DIAGONAL MIRRORS BOOST TELESCOPE PERFORMANCE

LUMICON 1.3" & 2.1" enhanced aluminum diagonal mirrors & 1¼" star diagonal.

The new LUMICON diagonal mirrors have a special enhanced aluminum coating with a protective overcoating for long life. Visible reflectivity is 94-96% compared to 86-89% for standard aluminum coated mirrors. The extra 5-10% transmission is like adding up to an inch of aperture! The substrate is fine annealed Pyrex flat to 1/8 wave.

1.32"	$39.50	1.52"	$45.00	1.83"	$49.50
2.14"	$59.50	2.60"	$75.00	3.10"	$99.50

ENHANCED ALUMINUM STAR DIAGONAL

90° star diagonals with 96% reflectivity enhanced aluminum mirrors in a CNC machined black anodized aluminum body. Performance far exceeds prism diagonals.

1¼" (1.32" mirror)	$99.50
2" (1.83" mirror)(see photo above)	$189.50

LUMICON FILTERS — BEST IN THE WORLD!

"The LUMICON O-III proved to be our favorite... It gave the greatest contrast gain." ***ASTRONOMY*, February 1991**

AMAZING O-III FILTER™

Helix Nebula, NGC 7293 in Aquarius. Bright and easy with Lumicon Oxygen-III Filter.

GREATLY ENHANCED DETAIL

"Consistently performed well on all emission and planetary nebulae. Detail and structure were greatly enhanced in the more than two dozen objects I viewed." ***SKY & TELESCOPE*, July 1995**

BETTER THAN A DARK-SKY SITE!?

"From my light polluted backyard, the view ... was better with the O-III than with any other filter tested. The view was even better than without the filter from a dark-sky site." ***SKY & TELESCOPE*, July 1995**

SEE THE HORSEHEAD!

*"**LUMICON's H-Beta Filter** will show subtle features in emission nebulae that the others fail to reveal. It can't be beat for the elusive Horsehead and California nebulae. . ."* ***SKY & TELESCOPE*, July 1995**

"I CAN SEE THE VEIL NEBULA!"

Rich Zepernick saw the Veil Nebula for the very first time with a **LUMICON UHC Filter**. He stated, *"It was actually there! and not just around 52 Cygni, but the whole loop! Words cannot possibly express my feelings. I don't know how I managed without these filters."*

Rich Zepernick, Cresskill, NJ

DEEP-SKY FILTER™

BEST for Astrophotography!

"Stunning is all I can say," says noted astrophotographer Jack Newton. Great for BOTH color and black and white photography.

BEST WIDE-BAND FILTER!

*"Based on our tests we'd recommend a LUMICON Deep-Sky and Oxygen-III as complementary filters. The LUMICON Deep-Sky Filter clearly had the best contrast for **reflection** nebulae."* ***ASTRONOMY*, February 1991**

	Premium*
LUMICON Multiple Filter Selector, holds 5 filters	**$129; $99** if ordered w/filter
1¼" LUMICON DEEP-SKY Filter threads into most 1¼" eyepieces	$99.50
48mm LUMICON DEEP-SKY Filter (1.7" aperture), threads into most 2" eyepieces. Also fits LUMICON EASY-GUIDERS	$199.50
2" LUMICON DEEP-SKY Filter (1.5" aperture), threads into most 2" eyepieces. Also has male & female camera T-threads for prime focus photography	$199.50
72mm LUMICON Giant DEEP-SKY Filter (62, 67, 77mm adapter, $10, 82mm $16)	$399.50
2" Rear Cell Filter, fits SCT's ... Deep-Sky, **$199.50** UHC, O-III, H-Beta,	$199.50
1¼" LUMICON UHC Filter threads into most 1¼" eyepieces	$99.50
48mm LUMICON UHC Filter (1.75" aperture) fits most 2" eyepieces	$199.50
Choice of ***any two*** LUMICON filters (**Save 7%**) ... 1¼" **$185.00**; 48mm	$370.00
LUMICON H-BETA Line Filter (9mm bandpass at 486nm). For the California Nebula, Horsehead Nebula, and other extremely faint nebulae. **1¼"** ... **$99.50, 48mm**	$199.50
Oxygen-III Filter for very faint planetary and diffuse nebulae, 11nm bandpass at 496nm and 501nm O-III lines ... **1¼" $99.50; 48mm**	$199.50
LUMICON Comet (Swan band) Filter ... **1¼" $99.50; 48mm**	$199.50
Telephoto lens adapter for 2" or 48mm filter. Select 46, 49, 52, 55, 58mm	$7.95
Universal adapter for 1¼" filters. Adapts the 1¼" filters to any 1¼" eyepiece	$19.50
Universal adapter for 48mm or 2" filters. Allows use of any 1¼" eyepiece	$25.00

**Premium filters are currently the best in the world. All Lumicon filters include individually measured transmission data.*

DEEP-SKY ASTROPHOTOGRAPHY

SR-V 3200 NEW FILM

ADJUSTABLE PIGGYBACK MOUNT

The LUMICON adjustable piggyback mount is ideal for telescopes of 6-16" aperture. It permits **both** vertical and sideways adjustment for optical alignment. Also ideal to mount LUMICON 80mm SUPER-FINDER™, large telephoto lenses and small telescopes up to about 5 lbs.

LUMICON Adjust. Piggyback Mount $59.50
Specify telescope size: 6", 8", 10", 11", 14", 16"

H-ALPHA PASS FILTER

Yields spectacular contrast gains in B&W photograph with telephoto lenses. Yields pinpoint star images. Superb with hypered 2415. For color, use the LUMICON Deep-Sky (DS) Filter.

Specify Lens Size	H-Alpha	(DS)
46, 48, 49mm	$59.00	$199.50
52, 55, 58, 62mm	$69.00	$199.50
67, 72, 77mm	$79.00	$399.50
82mm (77mm + adapter)	$89.00	$415.00

Hypered 2415 film, 36 exp .. **$11.95, $3/$32**

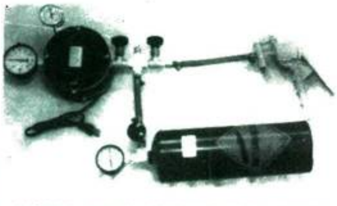
FILM HYPERSENSITIZATION KITS†

LUMICON HYPER-KITS™ yield 3-15x film speed gain in long exposures. They are safe & simple to use. Easy HYPER-KIT includes a chamber with all controls and fittings, thermometer, a refillable cylinder of non-flammable forming gas & hand-operated vacuum pump.

†U.S. Patent 4,473,636

MAKE YOUR OWN HYPERED FILM

MODEL 300 HYPER-KIT sensitizes any 35mm film in hours. Best for 2415. Achieves highest possible film speeds **$325**



MODEL 600 HYPER-KIT (See photo) Like the Model 300, but also sensitizes 120/220 larger format film and small glass plates **$395**

MODEL 1200 HYPER-KIT is for 4X5" plates and film up to 5X7". Has 2 gas cylinders and includes temperature controller ... **$595**

Temperature controller for any HYPER-KIT **$75**

Electric Vacuum Pump, Model R-10 **$325**

GUIDE OFF-AXIS FOR LOVELY ASTROPHOTOS

All **LUMICON EASY-GUIDER™** off-axis guiders† have both radial and 360° rotational adjustments for 5X easier guide-star selection, use 48mm filters, 360° camera rotation, large prisms for bright guide-stars. †U.S. Patent 4,448,500

Specify Camera and Telescope type.

NEWTONIAN EASY-GUIDER™

Full aperture. Installs in seconds. Specify 2" or 1¼".

NEWTONIAN EASY-GUIDER	$189.50
48mm Coma corrector/field flattener	$285
3X Relay Diagonal (see photo)	$99.50
Illuminated reticle eyepiece, pulsed	$119.50

Guider for Hasselblad **$489,** Mamiya 645 **$259**
Pentax 6X7 **add $129;** Pentax 645 **add $149**

CASSEGRAIN EASY-GUIDER™

For C-8, Meade 2080, Cynamax-8. Includes 50mm achromatic lens for f/5.8 operation—3X shorter exposures! **Superb rich field viewing, too!**

CASSEGRAIN EASY-GUIDER **$249.00**
Adapter for Hasselblad **$299,** Mamiya 645 **$98**
Pentax 6X7 **add $129;** Pentax 645 **add $149**

GIANT EASY-GUIDER™

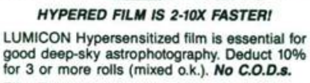
For Celestron-11, C-14, and the 10-12" Meade. Includes 80mm clear aperture achromatic lens for edge-to-edge illumination & pin-point star images. F-ratio adjustable f/4-f/11. **Also yields unmatched Rich-Field viewing.**

GIANT EASY-GUIDER **$395.00**
48mm DEEP-SKY Filter ordered with any EASY-GUIDER (SAVE $20) .... **add $179.50**
Adapter for Hasselblad **$399,** Mamiya 645**$149**
Pentax 6X7 **add $139;** Pentax 645 **add $159**

WHAT DO YOU NEED?

1. **Illuminated reticle eyepiece** ..... **$119.50** Lumicon 12mm eyepiece system has adjustable LED illumination, dual crosslines, pulsed.
2. **Cable release** for long exposures . **$9.95**
3. **Declination motor** (state telescope type) **$109**
4. **Dual-axis drive corrector** for telescope. This should be part of the telescope when purchased. Call LUMICON for details.
5. **LUMICON EASY-GUIDER** (selection to left) .
6. **LUMICON 48mm DEEP-SKY FILTER $199.50** This is essential for highest possible contrast. Contrast is boosted up to 3X for ***both*** color or black & white photos. The 3 photos in this ad showing the Helix Nebula, Horsehead Nebula and Veil Nebula were all made using a LUMICON 48mm DEEP-SKY FILTER.
7. **Hypersensitized film.** Purchase from LUMICON or make your own with a LUMICON HYPER-KIT.

TRY PPF! HYPERSENSITIZED FILM



HYPERED FILM IS 2-10X FASTER!

LUMICON Hypersensitized film is essential for good deep-sky astrophotography. Deduct 10% for 3 or more rolls (mixed o.k.). ***No C.O.D.s.***

Film Type, 35mm	Exposures	Price
Kodak PPF-400, THE BEST!	36	$14.95
2415, Ultra-fine B&W, red sens.	36	$11.95
SR-G3200, fastest of all, color neg	24	$13.95
Kodak Gold 1000 fast, fine grain	12	$13.95
Fuji G800 fine grain color neg.	24	$13.95
Ektachrome 1600, fast slide film	24	$14.95
Fujichrome RD100, fine grain slide	24	$12.95
D-19 B&W Developer	1 gal.	$8.50

LUMICON®

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LOTS OF ADAPTERS

2" adapter for C-8, Meade 2080, etc.	$29.50
2" adapter for C-80, C-100 refractor	$39.50
2" adapter for C-70, C-80F, C-100F fluorite	$39.50
2" adapter for C-6, Comet Catcher, Meade 312	$30.00

EXTENSION TUBES

1" long 1¼" OD thread-in extension	12.00
2½" long extension (holds 1¼" filters)	19.50
4½" long extension for 1¼" eyepieces	$29.00
3" long extension for 2" eyepieces*	$29.00
2" long extension for 2" eyepieces*	$29.00

VIEWING ADAPTERS

2"/1¼" reducing bushing, threaded 48mm*	$25.00
2"/T-thread adapter, threaded 48mm*	$25.00
T-thread/1¼" adapter	$25.00
F/10 2" or 1¼" eyepiece viewing adapter for Giant Easy-Guider	$59.50
Low profile star diagonal eyepiece holder	$16.00
Meade 2" Diagonal/Giant Easy-Guider	$39.50

**Threaded to hold 48mm filters.*

LED FLASHLIGHT . $14.95

LUMICON LUMILITE™ Red LED Flashlight

This red LED flashlight preserves night vision. Uses 2 AA cells (incl.) which last 60-100 hours.

LUMILITE red LED flashlight	$14.95
STARLITE™ adj. red LED flashlight	$24.95

RICH FIELD! 2° in 8" SCT

NOW ONLY
$99.95

LUMICON Rich-Field Viewer on C-8 with LUMICON 2" star diagonal and 2" eyepiece.

The LUMICON Rich-Field Viewer fits **all** commercial Schmidt-Cassegrain telescopes. It has a high-performance coated achromatic focal reducing lens with 50mm or 80mm clear aperture for **totally unvignetted viewing** with 2" or 1¼" eyepieces.

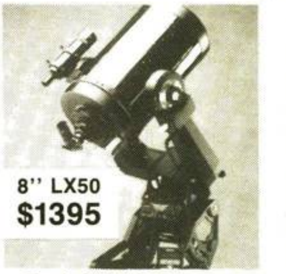
LUMICON Rich-Field Viewer (5-8")	$99.95
Giant Rich-Field Viewer (10-14")	$250.00

PENTAX 65° XL EYEPIECES

AMAZING performance! **All have** 20mm eye relief, adjustable eye guard, super multicoatings.

5.2mm F.L., 65° Apparent Field 1¼"	$279
7mm F.L., 65° Apparent Field 1¼"	$279
10.5mm F.L., 65° Apparent Field 1¼"	$269
14mm F.L., 65° Apparent Field 1¼"	$269
21mm F.L., 65° Apparent Field 1¼"	$269
28mm F.L., 55° Apparent Field 1¼"	$259
40mm F.L., 65° Apparent Field 2"	$299

MEADE 7" - 16" LX200
NEW! 7" - 10" LX50



8" LX50
$1395

16" LX200 $14,950

Meade 8" LX200 Telescopes

LX50 - includes dec. motor, hand controller.
LX200 - full computer control w/64K obj. mem.
Tripod: extra for LX50; included for LX200
NOTE: A wedge is **not** needed for visual observing with the LX200 Drive. Select f/10 or f/6.3 (no extra charge) for your LX200.

NEW! 3.5" f/14 ETX Maksutov ($20)	$595
ETX, showroom price *(no 8 month wait)*	$649
8" LX10 w/wedge, hand controller ($65)	$995
Field Tripod for 8" LX10 ($20 P&S)	$195
8" LX50 w/wedge ($115 P&S)	$1395
Adj. tripod for 8-10" SCT ($30 P&S)	$295
8" LX200 w/computer ($65 P&S)	$2795
Wedge for photographing w/8" LX200	$139
7" LX50 f/15 Maksutov w/wedge ($125 P&S)	$1795
10" LX50, f/10 w/wedge, dec. motor, hand controller ($155 P&S)	$1695
10" LX200 w/computer ($155 P&S)	$3195
12" LX200 (f/10 only)($215 P&S)	$4495
Super Wedge for photogr. w/10",12" LX200	$395
16" LX200 f/10 w/tripod ($385 P&S)	$14,950
Dew Shields: 8"	$119; 10" $129
12"	$189; 16" $289

PHOTOGRAPHY ACCESSORIES

Cassegrain EASY-GUIDER 4"—8", f/6 or f/10	$249
Giant EASY-GUIDER for 10"/12" f/4-f/10	$395

MEADE STARFINDERS

8" f/6
$749

New 8" f/6 Meade Starfinder telescopes

See the Meade ad in this magazine for full descriptions. These are complete telescope systems with motor drive & finderscope (equat. only), mount, and 25mm (=48X) eyepiece. New DC motor runs on 4AA batteries.

6" f/8 Dobsonian Starfinder ($46 P&S)	$349
6" f/8 Equat. Starfinder 6(add $79 P&S)	$649
8" f/6 Dobsonian Starfinder (add $59 P&S)	$449
8" f/6 Equat. Starfinder 8 (add $89 P&S)	$749
10" f/4.5 Dobsonian Starfinder ($85 P&S)	$599
10" f/4.5 Equat. Starfinder 10 (add $99 P&S)	$879
12.5" f/4.8 Dobsonian Starfinder ($95 P&S)	$895
16" f/4.5 Dobsonian Starfinder (freight COD)	$1195
16" f/4.5 Starfinder 16 (ship. freight COD)	$2695

*All Starfinder telescopes shipped directly from Meade to the purchaser. Please add the indicated packing & shipping charge to the price. Slightly lower P&S for payment by check. LUMICON showroom prices are $50-$100 higher.

ACCESSORIES

LUMICON carries all Meade accessories.

Magellan computer; specify Dob. or Eq. ($15 ship)	$295
LUMICON 1¼" UHC or O-III Filter	$99.50

Vinyl covers to keep dust-free (2 req.) for 6" - **$10**; for 8" - **$15**; for 10" - **$20**; for 16" - **$35**

SKY VECTOR™ $299!!

Includes Computer, Encoders, Hardware

LOW PRICE—from $299

LUMICON SKY VECTOR FEATURES:

- "GUIDE" mode leads you to object
- Digital right ascension readout to 1 min.
- Digital decl. readout to 10 arc-min.
- 4000 pulse (0.09° accuracy) encoders
- Polar alignment ***not required!***
- Motor drive ***not required!***
- Just sight two stars to align!
- Works **equally well** for alt-azimuth telescopes like Coulter Odyssey and equatorial mounts like C-8, Meade 2080.
- **No need** to enter latitude, longitude, etc.

SKY VECTOR I™ $299

NEW! With over 220 object memory including the 110 Messier and 58 best NGC objects.

SKY VECTOR II™ $349

Over 3600 objects! — Also includes planets and full visual descriptions.

NGC SKY VECTOR™ $439

12,000 **Objects!**— PC Serial Port

NGC-Sky Vector
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MODE
ENTER
UP
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LUMICON

NGC SKY VECTOR with IDENTIFY (Sky Tour) mode, 12,000 object memory including the corrected RNGC catalogue, IC catalogue, P&K planetary catalogue, & much more!

Specify Telescope Type: Meade 2045, 2080, 2120, C-8, C-11, Odyssey 8, 10, 13, 17½, Alt-Azimuth, Meade 6-16" Dobsonian.

Ultima 8, 9¼, 11 **add $25**, C-14 **add $75**

COMA CORRECTOR

Coma 1 inch off-axis 17½" f/4.5

Same field with LUMICON coma corrector; smaller, more numerous stars.

This computer-designed LUMICON 2" lens reduces coma and flattens the field for both viewing and photography. **It threads into LUMICON 2" EASY-GUIDERS for effortless installation.** This zero power lens does not change image scale nor shift focus, and all lens surfaces are multi-coated for highest efficiency. Clear aperture = 1.8".

LUMICON 48mm Coma Corrector/Field Flattener Lens	$285.00
LUMICON 2" EASY-GUIDER	$189.50
2" EASY-GUIDER (Mamiya 645)	$239.50
2" Adapter for Pentax 6X7	$129.00
2" Adapter for Hasselblad	$229.00
2" Adapter for Bronica SQ-A	$175.00
2" Extension for viewing	$26.00

2" DELUXE BARLOW

1.8x Multiplier Lens (2" Barlow)

LUMICON 1.8x Multiplier Lens (2" Barlow)	$259.00

LUMICON ACCESSORIES

LUMICON, Livermore, CA 94550 (925) 447-9570 FAX (925) 447-9589

LARGE UV/DUST SEAL

Protect the optics of your 8-14" Schmidt-Cassegrain with a UV/Dust Seal. Simply thread it onto the rear cell, then attach all normal accessories. The large size fits Meade 2120, Celestron-11 and -14 & has a high quality multi coated (removable) 72mm UV filter.

Deep-Sky Filter/Dust Seal for C-8, 2080	$199.50
UV/Dust Deal for Celestron C-8	$39.00
UV/Dust Seal for Meade 4"—8"	$39.00
UV/Dust Seal (lg.) for Meade 10"—12"	$89.50
UV/Dust Seal for Celestron-11, -14	$89.50

LOW PROFILE FOCUSERS
New! Thread-on for Odyssey

FROM $69.50

LUMICON® LOW PROFILE FOCUSERS

LUMICON now offers 3 different low-profile helical focusers. They stand only 1¼-1½" above the telescope tube. Use the 1¼" or 2" versions for viewing. Use the 2" non-rotating focuser for convenient photography with the LUMICON 2" EASY-GUIDER™.

Select your desired base-plate shape! Coulter Odyssey (thread-on installation), Flat, 7" OD, 9½" OD, 12½" OD, 16" OD, 21" OD.

LUMICON 1¼" Helical Focuser	$69.50
LUMICON 2" Helical Focuser 1½" high	$75.00
LUMICON Non-rotating Helical Focuser	$129.00
2" Astro Systems focuser, only 2" high	$139.00
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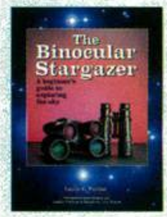

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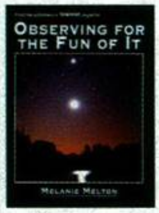

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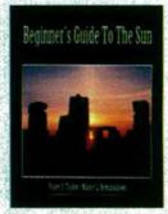

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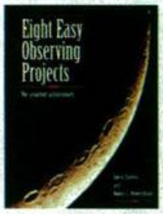

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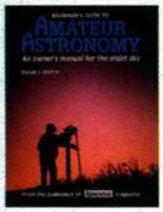

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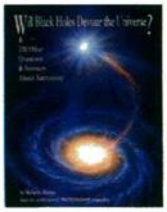

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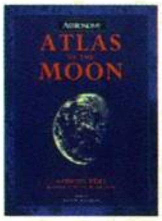

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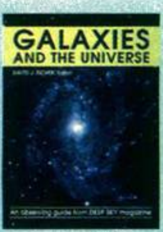

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The View from Titan, Why Planets Don't Twinkle, Black Holes

Q: How would Saturn look if I were on its moon Titan? *— Jake Rosenbaum, Chesapeake, Virginia*

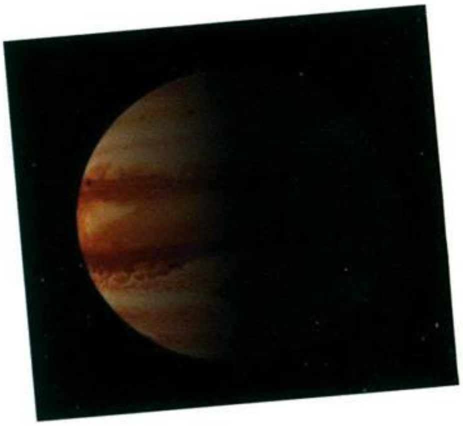
A: Titan has a thick, hazy atmosphere, so you probably wouldn't even see Saturn if you were standing on Titan's surface. But if you were in a spaceship just above Titan's cloudtops, a fully or partially illuminated Saturn would be spectacular. The planet itself (not including the rings) would appear 5.6° across, about 11 times the width of a full moon in Earth's sky. The rings would span an astonishing 12.8° (almost 26 full moons!). Even with the naked eye, you could see bands, storm systems, and color variations in Saturn's upper cloud deck.

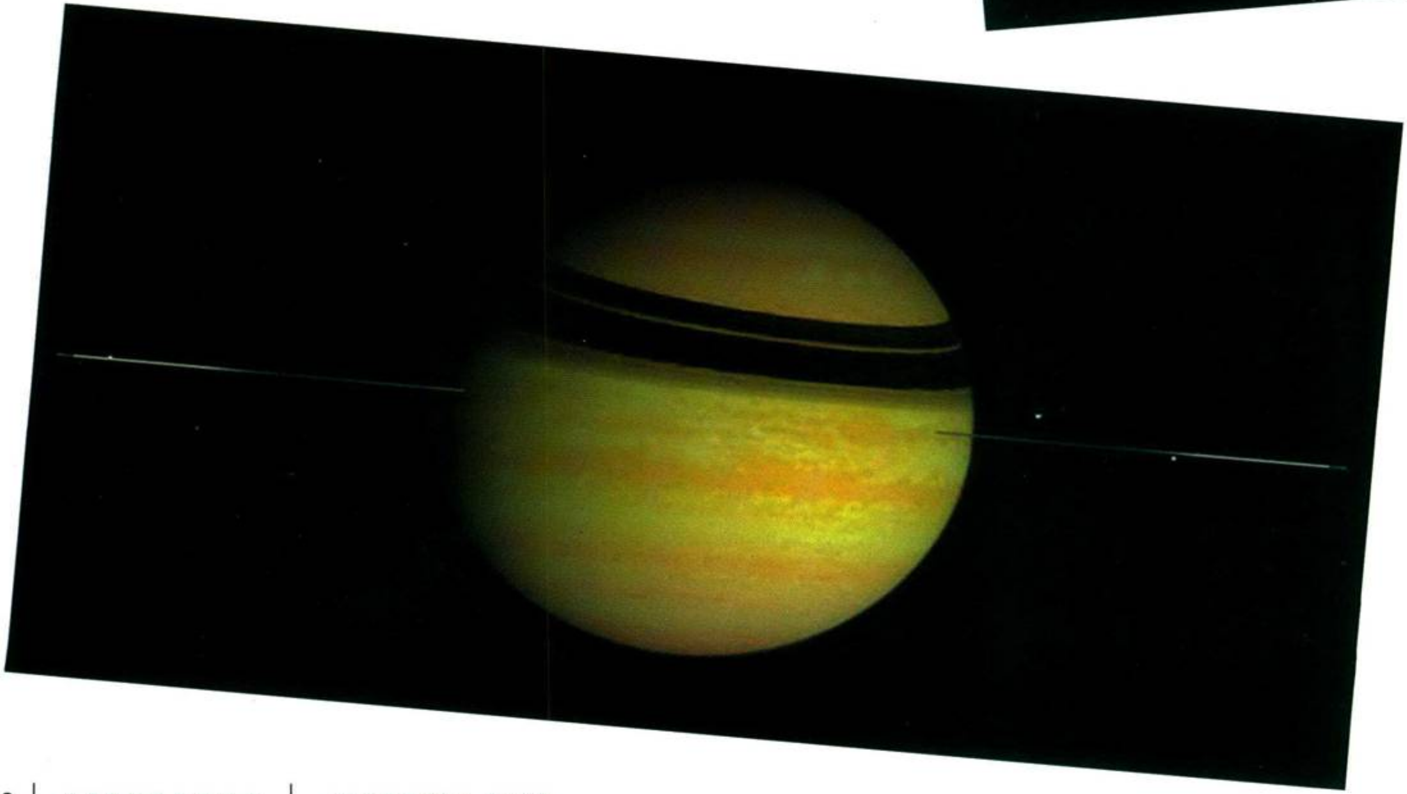
Saturn as seen from Titan would be a glorious sight (below). David Seal/NASA/JPL/Caltech

To show people how the solar system's planets and moons would appear from other planets and moons, artist David Seal, working at NASA's Jet Propulsion Laboratory, created a wonderful website at: http://space.jpl.nasa.gov/. In general, the planets and moons appear larger on your computer screen than they would appear to your naked eye, but the simulations (three examples are shown here) present the correct phases and orientations of the various bodies at different times. For fun, try inputting different times and dates to see how a planet's appearance changes as a moon goes around it. Check it out! — *Robert Naeye*

If you were standing on Jupiter's moon Io, the appearance of the planet would change considerably in 12 hours as the moon races around its 1.8-day orbit (right).

David Seal/NASA/JPL/Caltech





Q: I've heard that stars twinkle because their light gets bent as it passes through Earth's atmosphere. Because planets' light also has to pass through the atmosphere, why don't planets twinkle? *— Jessica Reynolds, Ashland, Oregon*

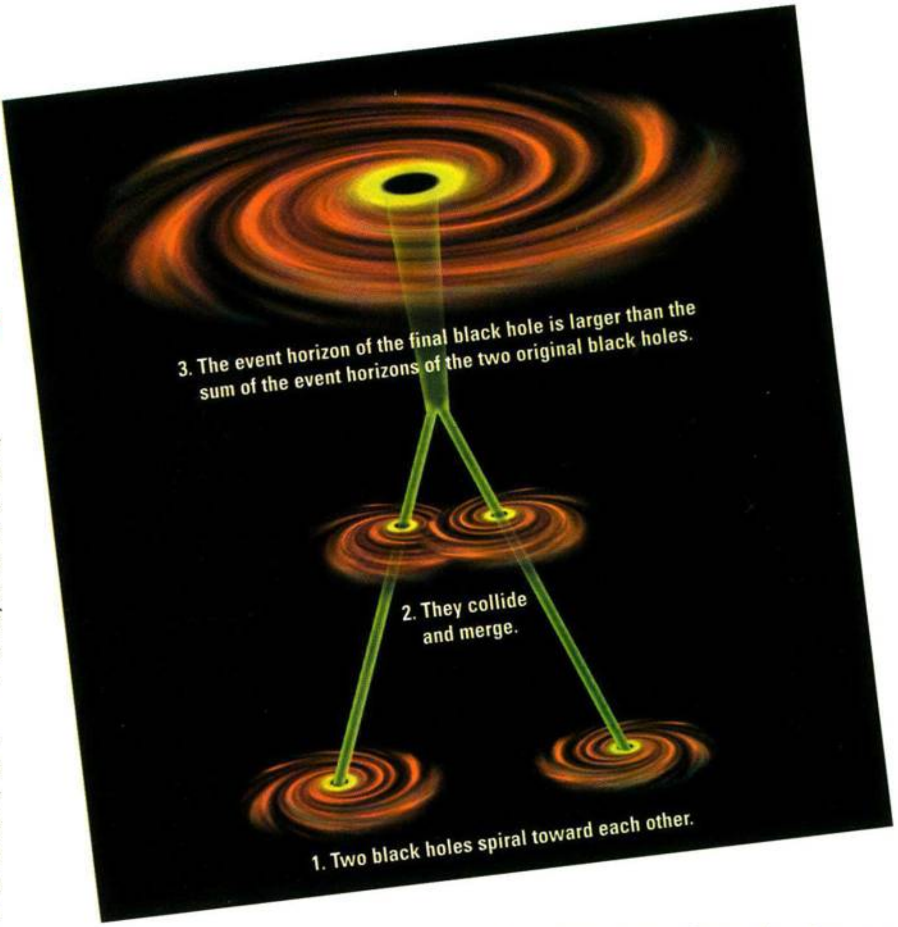
A: Stars are very far away, so they appear as almost infinitely tiny points of light. As that light passes through our atmosphere, it gets refracted, or bent, by the air. Because air at different pressures bends light by different amounts, each incoming photon of light from a pointlike star seems to come from a slightly different direction — what we see as twinkling.

Planets, on the other hand, are relatively close and, although it may not look like it to the naked eye, actually appear as small disks. Although light from a planet's disk is also bent slightly, to the unaided eye most of the light still appears to be coming from the disk. The atmosphere simply makes the planet's disk appear a bit larger. Fine detail seen through a telescope might look smeared, but to the naked eye, a planet shines through steady and clear. — *John Shibley*

Q: What happens if two black holes collide? *— Randy Constantine, St. John's, Newfoundland; Karl Wiensz, Rickreall, Oregon; Skylar Thompson, Appleton, Wisconsin; and Mark Odegard, Waukon, Iowa*

A: When black holes collide, they can merge together to form a single black hole — like two trouser legs joining together near the waist.

An interesting feature that I realized while I was getting into bed one night in 1970 is that the area of the event horizon, or boundary, of the final black hole has to be greater than the sum of the areas of the event horizons of the original black holes. This limits the amount of energy that can be radiated in gravitational waves and also suggested that the area of the event horizon is like the thermodynamic quantity entropy, a connection that was established when I later showed that black holes radiate like hot bodies (see "Devouring the Future," page 64). — *Stephen Hawking, Cambridge University*


3. The event horizon of the final black hole is larger than the sum of the event horizons of the two original black holes.
2. They collide and merge.
1. Two black holes spiral toward each other.

When two black holes merge, they form a single black hole with an outer boundary larger than the boundaries of the two original black holes added together.

Astronomy: Elisabeth Rowan

Q: Is there an upper limit to the mass of a neutron star as there is to the mass of a white dwarf (1.4 solar masses)? *— David Weinflash, New York, New York*

A: There is indeed an upper limit to the mass of a neutron star: between two and three solar masses. As with white dwarfs, the larger the mass, the greater the weight of material that the matter in the star must hold up. If we could keep piling material onto a neutron star, eventually the star would not be strong enough to support its own weight, and gravity would crunch it down into a black hole. We don't know precisely how massive a neutron star can be because we don't know how stiff matter is near the center of a neutron star, where the density is much greater than the matter inside a normal atomic nucleus.

Astronomers hunting for black holes need to know the maximum mass to tell whether a compact object that they find in the universe, in a binary x-ray source for example, could be a neutron star or whether it must be a black hole. Observers have generally assumed a lower limit of at least 3.2 solar masses in identifying black holes. We now know that the upper mass of a neutron star must certainly be less than 2.9 solar masses and could be as little as 2.2 solar masses. With such a smaller limiting mass for neutron stars, many compact objects that were previously assumed to be neutron stars must in fact be black holes. — *Gordon Baym, University of Illinois* ■

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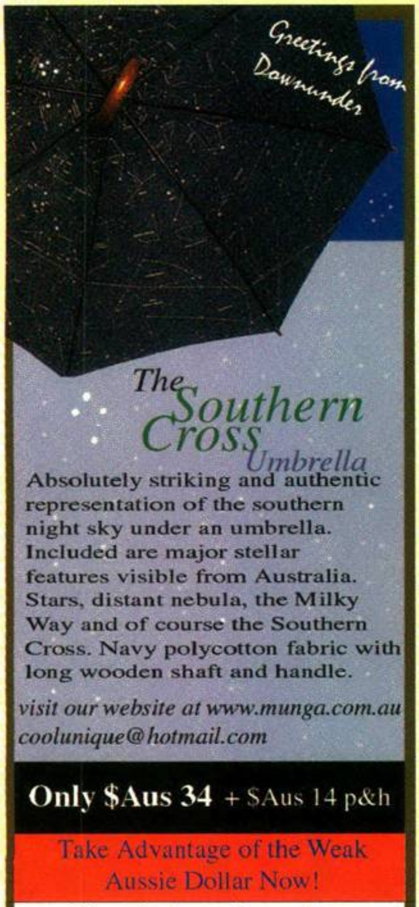

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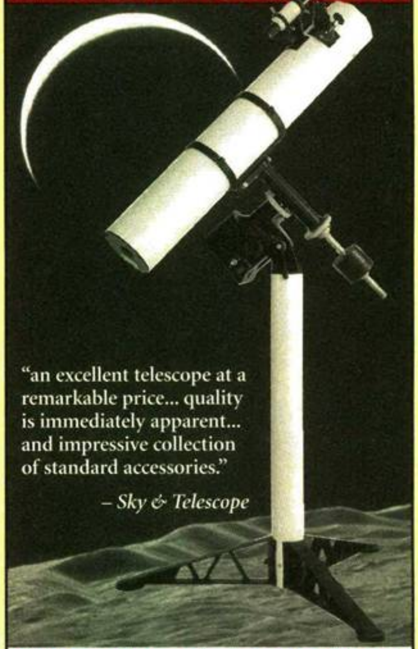
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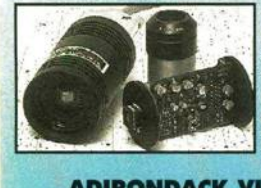

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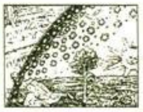

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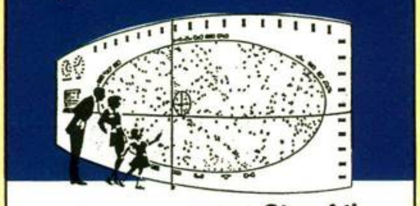

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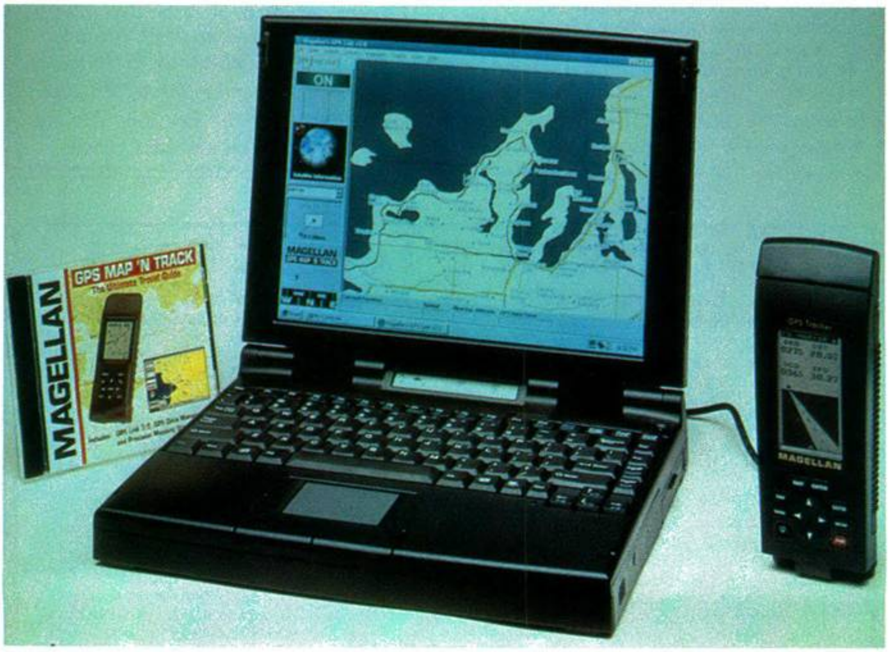
▶ If you're in search of a dark sky site or just want to know the exact longitude and latitude of your current observing site, Magellan's new portable Map 'N Tracker PC navigation kit may be for you. The package combines Magellan's Global Positioning System (GPS) receiver technology with the company's CD-ROM mapping software. Map 'N Tracker enables users to see on their personal computer a custom, detailed map showing where they are and where they are going.

Map 'N Tracker features in-vehicle navigation by connecting the GPS receiver to your laptop. Once you've launched the street atlas software, you can view your current position and all surrounding streets on a moving map display. The system also gives you directions, distance to go, speed, and other vital navigation information. The Map 'N Track software lets you locate individual street addresses, cities, states, telephone area codes, ZIP codes, and latitude and longitude coordinates in the United States.



Map 'N Tracker can import and display geo-referenced digital maps, background images, satellite imagery, and terrain data. By scanning any printed street or topographical or nautical map then inputting the latitude and longitude of four points on that map, you can create your own digital guide.

The system is designed to work with *Windows 3.1*, *Windows 95*, and *Windows NT*. It includes a GPS tracker, CD-ROM, PC interface cable, and user instructions.

Magellan Corporation, 960 Overland Court, San Dimas, CA 91773; phone, (909) 394-5000; fax: (909) 394-7050; website, http://www.magellangps.com. Map 'N Tracker PC: $329.99.

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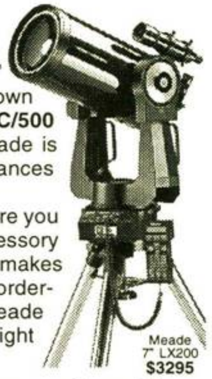
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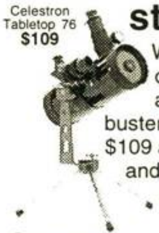
Celestron Tabletop 76 $109

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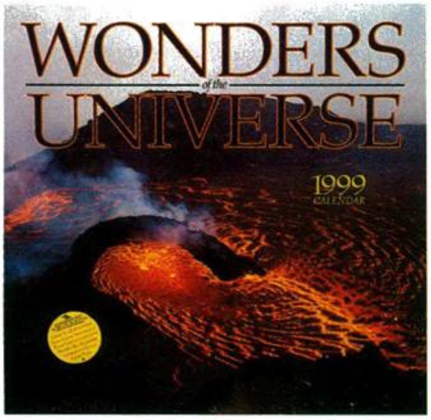
Wonders of the Universe

▶ Hansen Planetarium Publications is proud to present its 1999 *Wonders of the Universe* calendar. Enjoy the endless beauty of the universe represented in 12 spectacular full-color photographs taken by photographers, observatories, and space agencies. The calendar provides month-by-month details of planetary movements, lunar phases, lunar occultations, and space-science anniversaries all in a large 12" by 24" format.


WONDERS
of the
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1999
CALENDAR

Settle into the New Year by floating through an Alaskan aurora then move toward an ethereal lenticular cloud over Mt. Rainier. Journey onward with the Hubble Space Telescope to view the stunning collision of the Antennae galaxies, the massive stellar blowout of Eta Carinae, and more.

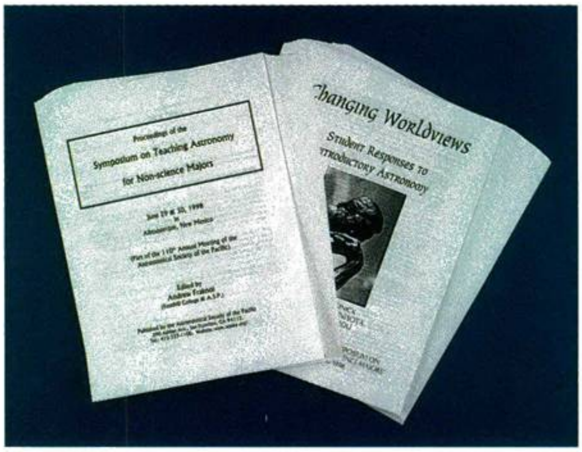
Hansen Planetarium Publications, 1845 South 300 West #A, Salt Lake City, UT 84115; phone, (800) 321-2369; fax, (801) 483-5484. 1999 Wonders of the Universe calendar: $11.95 plus shipping.

Teaching Astronomy to Non-Science Majors

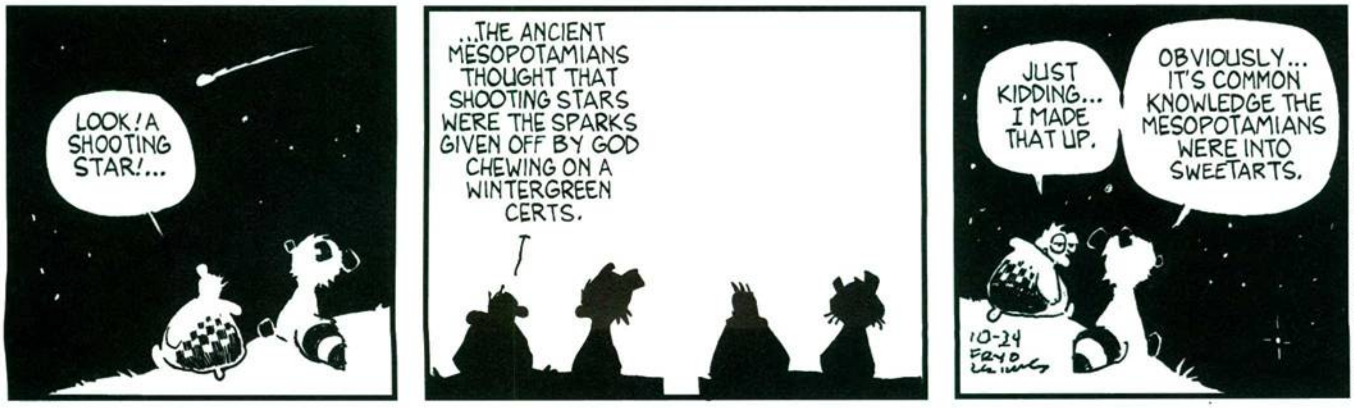
▶ The Astronomical Society of the Pacific (ASP) has compiled the handouts given to participants at their *National Symposium on Teaching Astronomy to Non-Science Majors*. Roughly 150 instructors from a wide range of colleges and universities participated in the symposium that was held during the ASP's 110th Annual Meeting in Albuquerque, New Mexico, last June. All speakers were asked to bring a concise summary of their presentations in handout form.

As a result of strong interest from instructors world-wide who were unable to attend, the ASP has agreed to offer a 300-page compilation of the symposium's handouts. The package is collated but not bound and includes an introduction to the main themes as well as a table of contents, both written by Andrew Fraknoi, conference moderator.

These handouts include course syllabi, innovative ways to handle large-lecture classes, clever lab exercises, research results on teaching and learning, new uses of the World Wide Web, student project ideas, teaching resource guides, and much more.


Proceedings of the
Symposium on Teaching Astronomy
for Non-science Majors
Changing Worldviews
Student Responses to Introductory Astronomy

To obtain a set, send a check to: Astronomical Society of the Pacific, attention: Symposium Handouts, 390 Ashton Avenue, San Francisco, CA 94112. Teaching Astronomy to Non-Science Majors: $24.95 for those living in the United States, $32.95 (in U.S. funds) for those outside the United States, prices include shipping and handling. Be sure to include your name and the address to which you want the package shipped. Purchase orders cannot be accepted for this special offer.


LOOK! A SHOOTING STAR!...
...THE ANCIENT MESOPOTAMIANS THOUGHT THAT SHOOTING STARS WERE THE SPARKS GIVEN OFF BY GOD CHEWING ON A WINTERGREEN CERTS.
JUST KIDDING... I MADE THAT UP.
OBVIOUSLY... IT'S COMMON KNOWLEDGE THE MESOPOTAMIANS WERE INTO SWEETARTS.
10-24
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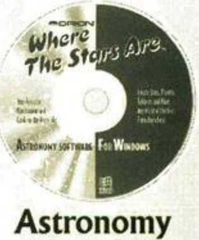

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BOOKS

Skeptics and True Believers: The Exhilarating Connection Between Science and Religion

Chet Raymo, 288 pages, Walker Publishing Co., New York, 1998; ISBN 0-8027-1338-6; hardcover, $22.

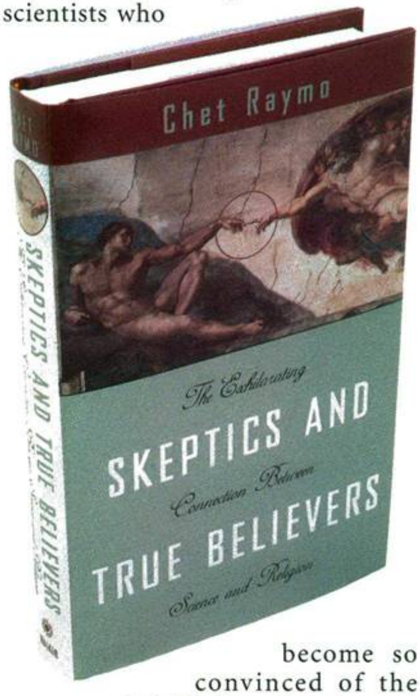
▶ Why is it that in a society that values the free exchange of ideas, religion is still an uncomfortable subject? Chet Raymo goes at the topics of religion, politics, and science in a new book, *Skeptics and True Believers: The Exhilarating Connection Between Science and Religion*. He takes a no-holds-barred attitude, that yields a provocative and important book on a tough range of subjects.

Raymo writes a weekly science column for the *Boston Globe* in which he explores the many ways that scientific discovery serves us in our daily lives. He is an ambassador for the scientific community, helping the general public understand how highly technical and specific experimentation eventually finds its way to making our lives better. Ironically, as a science writer he continually finds himself having discussions with his readers about religion. As he puts it, "No topic has evoked more reader response than the intersection of science and faith."

Unfortunately, what Raymo has found is that more often than not, this intersection is actually a great rift. People of strong religious faith seem to reject science; people well-versed in the scientific method seem to reject the validity of religious belief and of a religious response to the natural universe. Troubled by this rift of understanding and lack of tolerance, he set off in his book to show that this type of division is not only unnecessary but harmful.

There are two types of people in the world: Those who divide the world into two types of people, and those who do not. Raymo is one of the first types. Central to his book is the idea that you are either a *Skeptic* or you are a *True Believer*. Skeptics are open to new and varied ideas, yet they require constant, testable, and observable verification of the facts. This disposition makes them inclined to support progress. Raymo calls them "children of the Scientific Revolution and the Enlightenment." True believers, on the other hand, come to the table with their ideas pre-formed and no amount of factual evidence to the contrary can change their minds.

This is an interesting dichotomy, and Raymo's development of it ranges from the downright silly and simplistic Credulity Index ("Are you a skeptic or a true believer? Try this test to measure your Credulity Index") to insightful and provocative examples. For instance, he points out that many great religious leaders were, by all rights, skeptics. He also warns against scientists who become so convinced of the infallibility of their work that they become true believers.


Chet Raymo
The Exhilarating Connection Between Science and Religion
SKEPTICS AND TRUE BELIEVERS

Most of us are probably a little bit of both. This split way of thinking yields Raymo's second — and more important — point. Even true believers welcome science when it benefits them (better medicine, improved communication, increased production, etc.) yet they "firmly reject one of its clearest implications: Human beings are ephemeral, contingent parts of a silent universe that is vastly larger than ourselves." The problem with this for Raymo is that the cold facts of science do not make us feel personally significant, so we turn to superstition, pseudo-science, and religion to fill the gap. This squelches our ability to develop a deeper, scientific understanding of the universe and of our ability to cope with and exploit the real forces of the universe.

Raymo argues that science is not just cold facts, but instead shows us how spectacular, infinite, and beautiful our universe is. He believes that by immersing ourselves in this deeper understanding, we can learn to feel religious awe at the grandeur and find meaning in the fact that we are a part of such a marvelous universe.

Ultimately, Raymo's argument is unconvincing. As the book continues, he sounds a bit like a true believer himself, especially when he quotes different authors who have been influential in his search for a religion that holds up to science. Some seem to be less than scientific, and Raymo even admits this about one but quickly adds that "many of [the quoted author's] intuitions strike me as on the mark."

This lapse is not important enough to slow down the compelling force of Raymo's discussions or to throw the main line of his arguments off track. He still forces you to think about your own ideas and beliefs in a progressive and introspective manner. His bravery in tackling such an elusive subject is in line with the best scientific minds and their unquenchable desire to know and understand more. His insight is keen and sometimes embarrassing as he points out ways that we gloss over flaws and inconsistencies in our thinking.

He also has a fantastic ability to describe the miracles and mysteries that science has shown us in nature. He convincingly makes the point that greater scientific knowledge opens up a world of even greater mysteries. His passion for science is contagious.

Some books are considered good or important for what they contain. They may be full of solid or interesting facts, funny, or have an exciting story line. Others are considered important not for their content, but for the response they provoke. *Skeptics and True Believers* falls into the second category: As you read it, you'll be forced to think and rethink through comfortable assumptions concerning science, religion, and the nature of the relationship between the two.
— *Curtis Baldwin Strohl*

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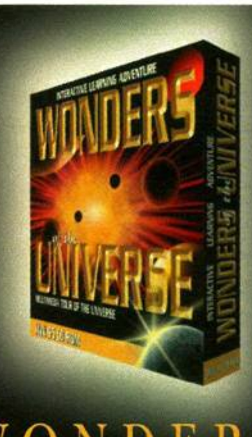

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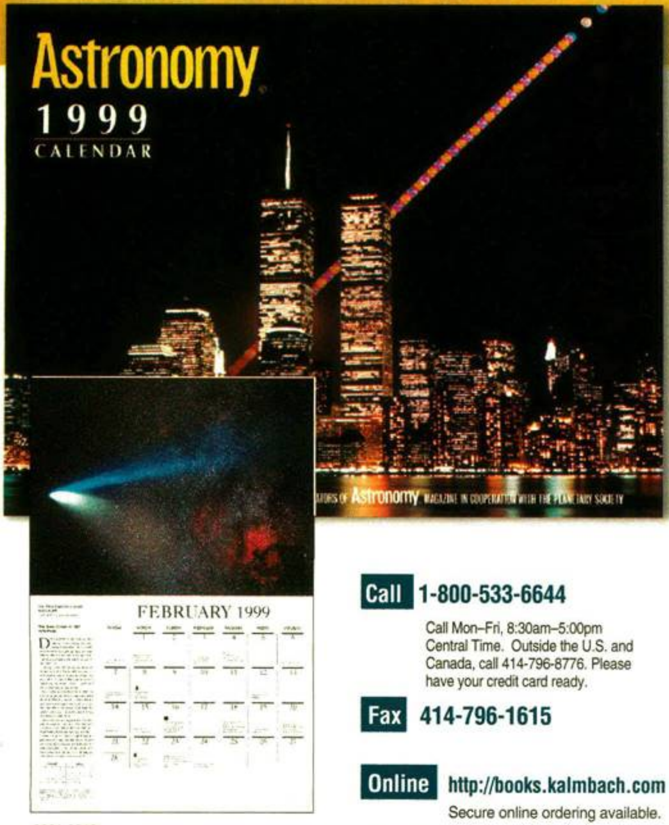

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BYTES

Ancient Astronomy

Explore five world-famous archaeoastronomical wonders without a passport, visas, or those nasty shots. *StarSites*, a multimedia journey, takes the curious on an exploration of how humans through the ages have used architecture to better understand the heavens. It also helps to explain the ancient connection between human imagination and the night sky.

The starting point for your journey is an interface of concentric circles, which evokes the configuration of the standing stones at Stonehenge. A series of interactive maps and three-dimensional models then guides you to one of the five *StarSites*.

Discover the Pyramids of Giza — interpreted to be a representation of the constellation Orion — and the Egyptians' way of death. Some believe the pyramids to be symbolically connected with the sun's nighttime journey through the underworld or the land of the dead.

Deep in the jungle of Honduras, at Copán, you'll find a simple observatory and a stadium devoted to blood sport. The observatory functioned as a celestial calendar based on the cycles of Venus. The ball game played in there is thought to be connected to the sky: A ball representing the sun had to be kept in the air. When it hit the ground, the player at fault was sacrificed.

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The next stop is a unique and spectacular site in Jaipur, India. Jantar Mantar is a stone observatory that was created within a palace in 1732. It represents one man's ambition, to create star maps more accurate than any that had been drawn up to that time.

You will also visit the Celtic "theatre of the dead" at Newgrange in Ireland. The structure was built 5,000 years ago. It was designed to draw sunlight through a small hole in an artificial mound. Once a year, on the morning of the winter solstice, the sun shines through the roof box and along the length of an underground passage. This beam of light is believed to have served as the stage lighting for a "theatre of the dead."

The last of the five *StarSites* is the Forbidden City in China. This structure was built to mediate between heaven and Earth. The Forbidden City was designed to reflect the shape of the heavens as portrayed in Chinese myths. Just as Polaris, the pole star, lay at the center of heaven, so too the emperor took his place at the heart of the Middle Kingdom. Every year, as the seasons changed, he circled the Forbidden City and visited temples representing heaven, Earth, the sun, and the moon.

DNA Productions, Inc., Suite 230, 1737 West 3rd Avenue, Vancouver, BC V6J 1K7 Canada; phone, (604) 730-0306; fax, (604) 732-7331; website, http://www.dna.bc.ca. Starsites: $39.95 plus shipping and handling.

The Webweaver Picks

The holiday season always brings questions about the Star of Bethlehem's identity. This month we focus on some interesting websites that offer surfers the chance to ponder the questions themselves.

The first site, "The Star of Bethlehem," presents an article that appeared in the December 1993 issue of *IMPRIMIS*, the monthly journal of Hillsdale College in Michigan. It was written by Craig Chester who is president and a co-founder of the Monterey Institute for Research in Astronomy.

The second site, "The Wise Men and the Star of Christ" by the Reverend Phil Greetham, leads visitors through several pages of explanatory text while presenting arguments for and against each idea proposed, be it astronomical or theological.

The final site offered this month comes from the producers of *Earth & Sky*. "The 'Stars' of Bethlehem" gives an overview of the current theories.

The Star of Bethlehem
http://listserv.american.edu/catholic/other/star.bethlhem

The Wise Men and the Star of Christ
http://ourworld.compuserve.com/homepages/p_greetham/wisemen/home.html

The "Stars" of Bethlehem
http://www.earthsky.com/specials/stars_of_bethlehem.html

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Lenshood 12"	174
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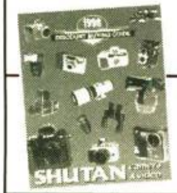

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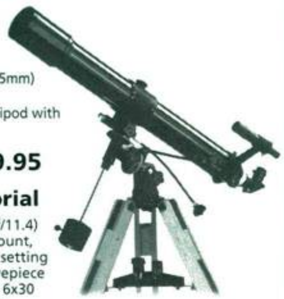

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BACKYARD ASTRONOMY

Wanna See Five Planets?

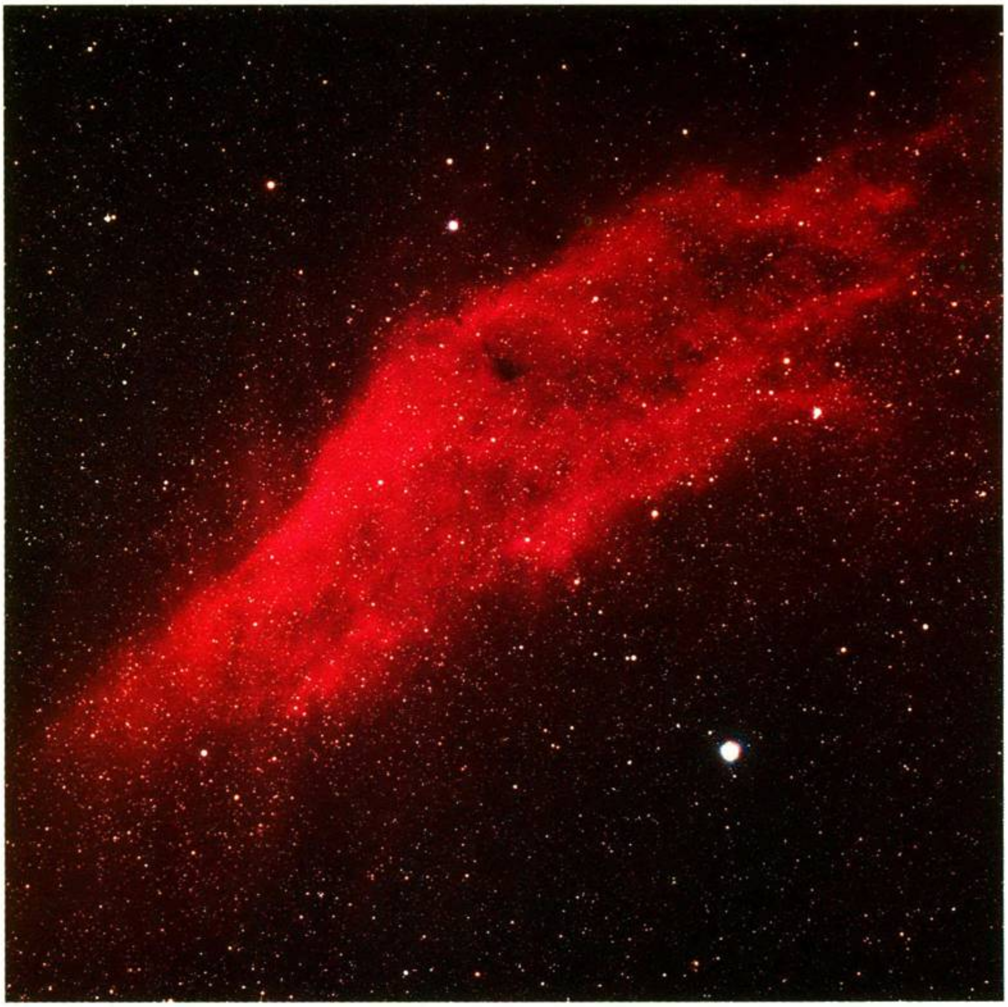
A father and his children enjoy autumn astronomy

▶ "Hey kids, who wants to see five planets?" That's how the evening started on October 24, 1997. I'd noticed Venus and Jupiter in the night sky and pulled the October *Astronomy* out of the stack, checking to see what else might be visible. Mars near Venus. Saturn at opposition. What a chance. In my suburban location, I'm pretty much limited to viewing solar system objects, and this was about as good as it gets.

At dusk, I carried my 4.5-inch reflector out to the golf course that abuts my backyard, to escape the streetlights and to view away from trees. I oriented the scope and invited my three children, ages 8, 7½, and 6, to join me.

The night was a beautifully warm, Indian-summer evening. Autumn was coming, but a warm breeze still wafted across the links. The moon was not yet up. I found a spot from which all the bright planets were visible. "See that bright star? That's not a star; that's the planet Venus. See the red one near it? That's Mars, the Red Planet, the one the robotic spacecraft is exploring. Look up. That bright one overhead is Jupiter, and the one over there is Saturn. The fifth planet? Look down — it's Earth and you're standing on it."

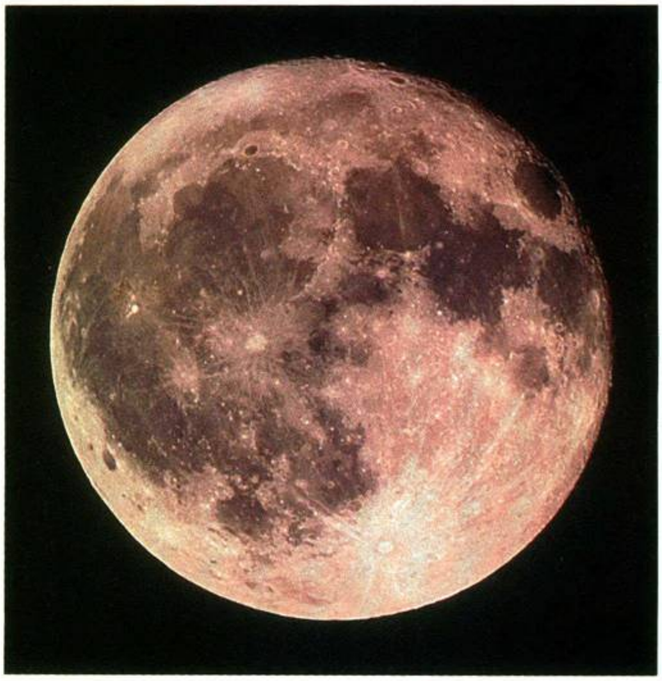
First we looked at Venus. Everyone got a look at each



The California Nebula in Perseus

GEORGE GREANEY

(6-inch f/7 apochromatic refractor, composite of two 60-minute exposures)



Full Moon Rising

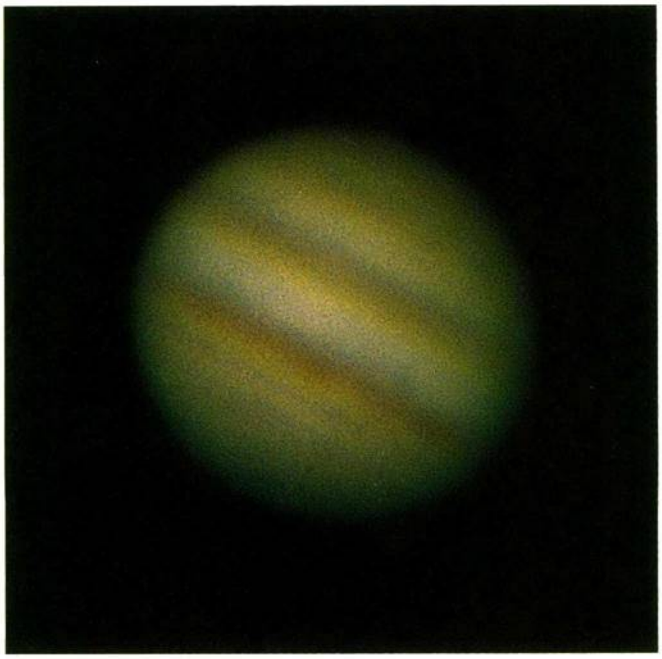
BILL AND SALLY FLETCHER

increase in magnification while I asked what was unusual about the planet. Eventually the crescent shape became apparent. This was pretty exciting because we had been "noticing" the moon all month and we'd talked about why the moon exhibits phases. So I explained the phases of Venus. Next came Mars — but just then the golf course sprinklers chased us to a new spot. Mars was nothing special, but appeared clearly as a ruddy disk. About then, we noticed that Venus was gone. I explained about Earth's rotation and that stars and planets rise and set just like the sun and moon.

Next on the tour came Jupiter. Again, I solicited comments from my junior observers. "Describe what you see. A big dot? Small dots? What shape do they make?" We saw three Galilean moons, clearly arrayed in a line across Jupiter, and we talked about Galileo — the man and the spacecraft. Finally, we viewed Saturn. As higher power eyepieces slipped in, it became decidedly oval. Then we saw the rings and another moon.

The kids were thrilled, and so was I. Several little lessons on the solar system in just half an hour. Good thing it was quick, because the kids' attention spans were expended at this point. Not so for Dad, though. I found Uranus and Neptune. It was one of the most enjoyable nights of observing I recall, rivaling the night I spent half an hour staring at Comet Hyakutake. ■

Steve Trimberger is an amateur astronomer living in San Jose, California.



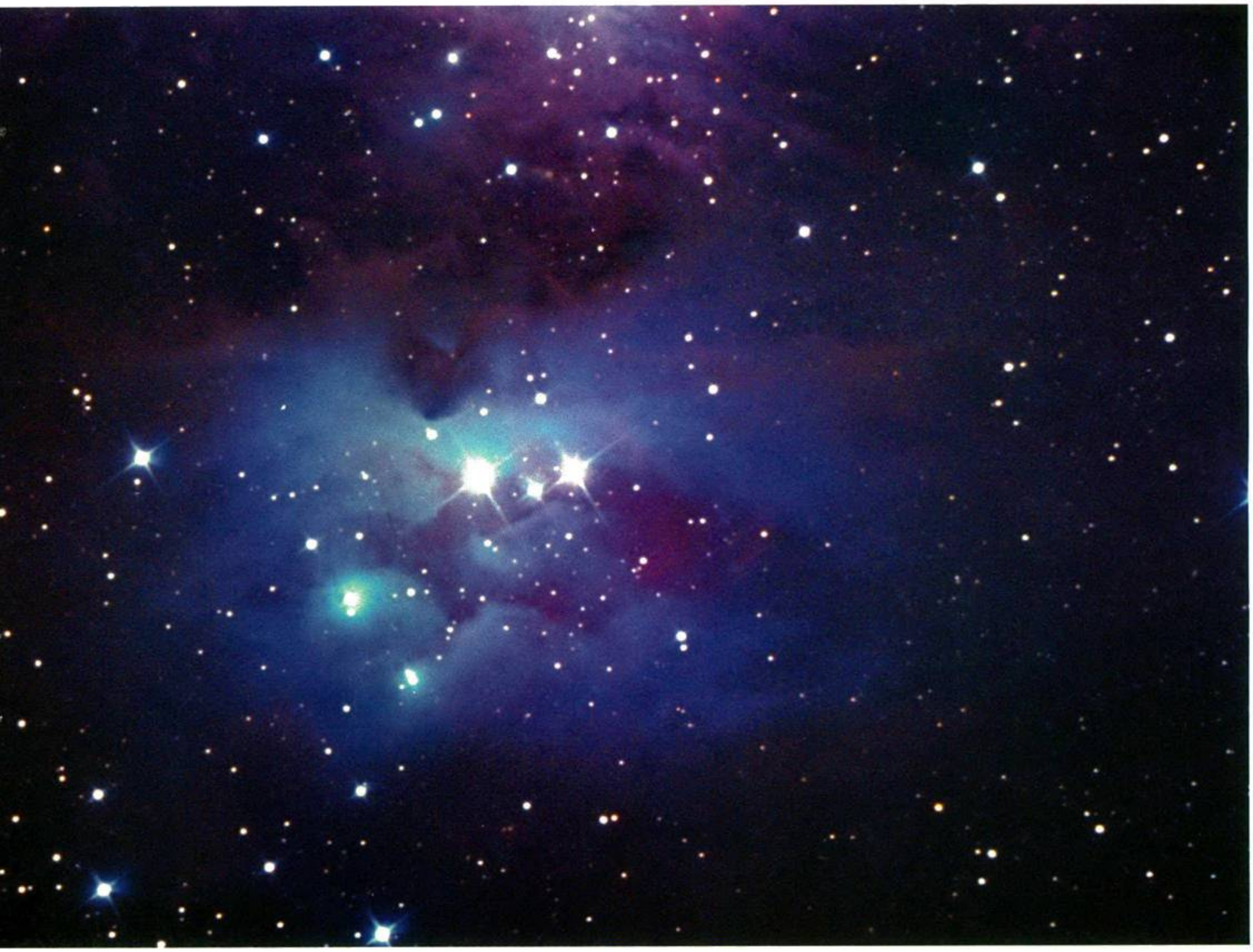
The Gas Giant Jupiter

PHILIPPE DURVILLE

(9-inch reflector at f/145, Kodak Gold 400 film, 6-second exposure taken September 21, 1997)

The Waning Moon Two Days Before New

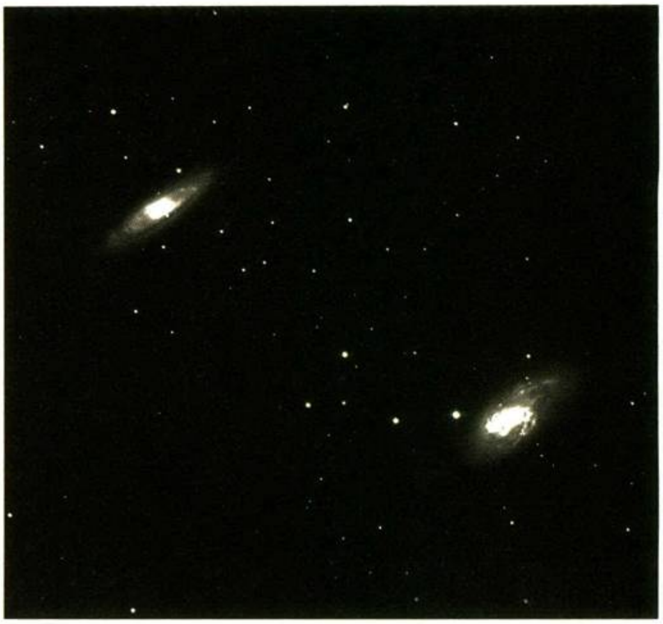
JERRY SCHAD



Reflection Nebula NGC 1973–5–7 in Orion

CHRIS SCHUR

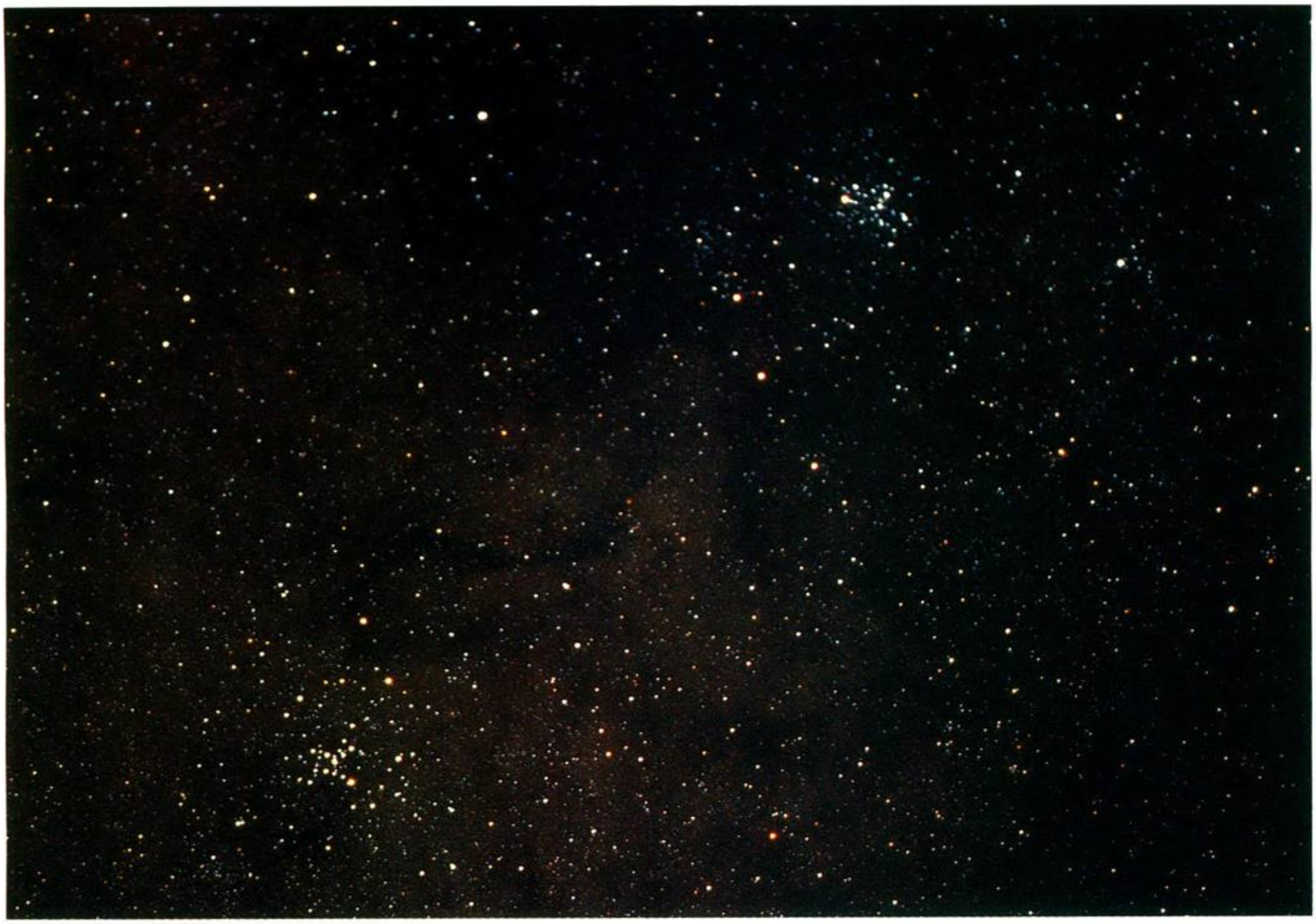
(12.5-inch f/5 reflector, hypersensitized Kodak Pro 400 PPF film, composite of two 45-minute exposures)



Galaxies M65 and M66 in Leo

PRESTON SCOTT JUSTIS

(10-inch f/6 reflector, hypersensitized Tech Pan film, 65-minute exposure)



Star Clusters M6 and M7 in Scorpius

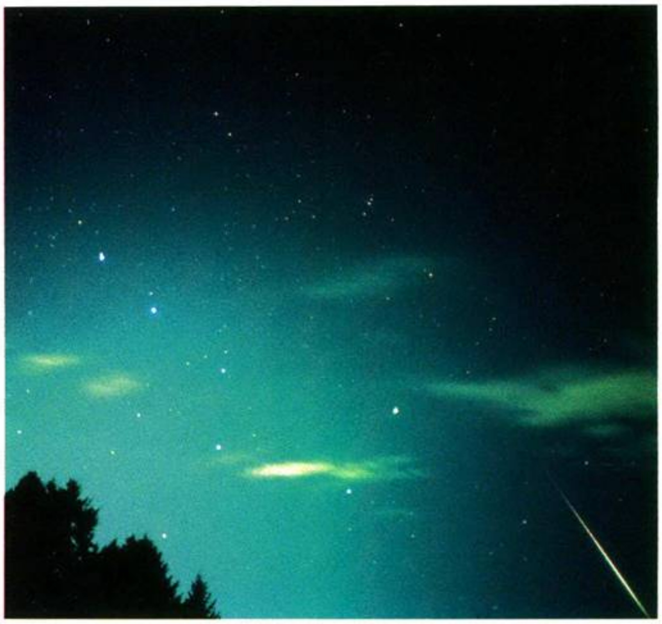
TIM BARNWELL

(300mm lens at f/2.8, Ektachrome 400 film, 10-minute exposure)

A Perseid Fireball Dives Toward the Horizon

JOHN FLINN

(35mm lens at f/1.4, Fuji Provia 400 film, 10-second exposure taken August 12, 1996)

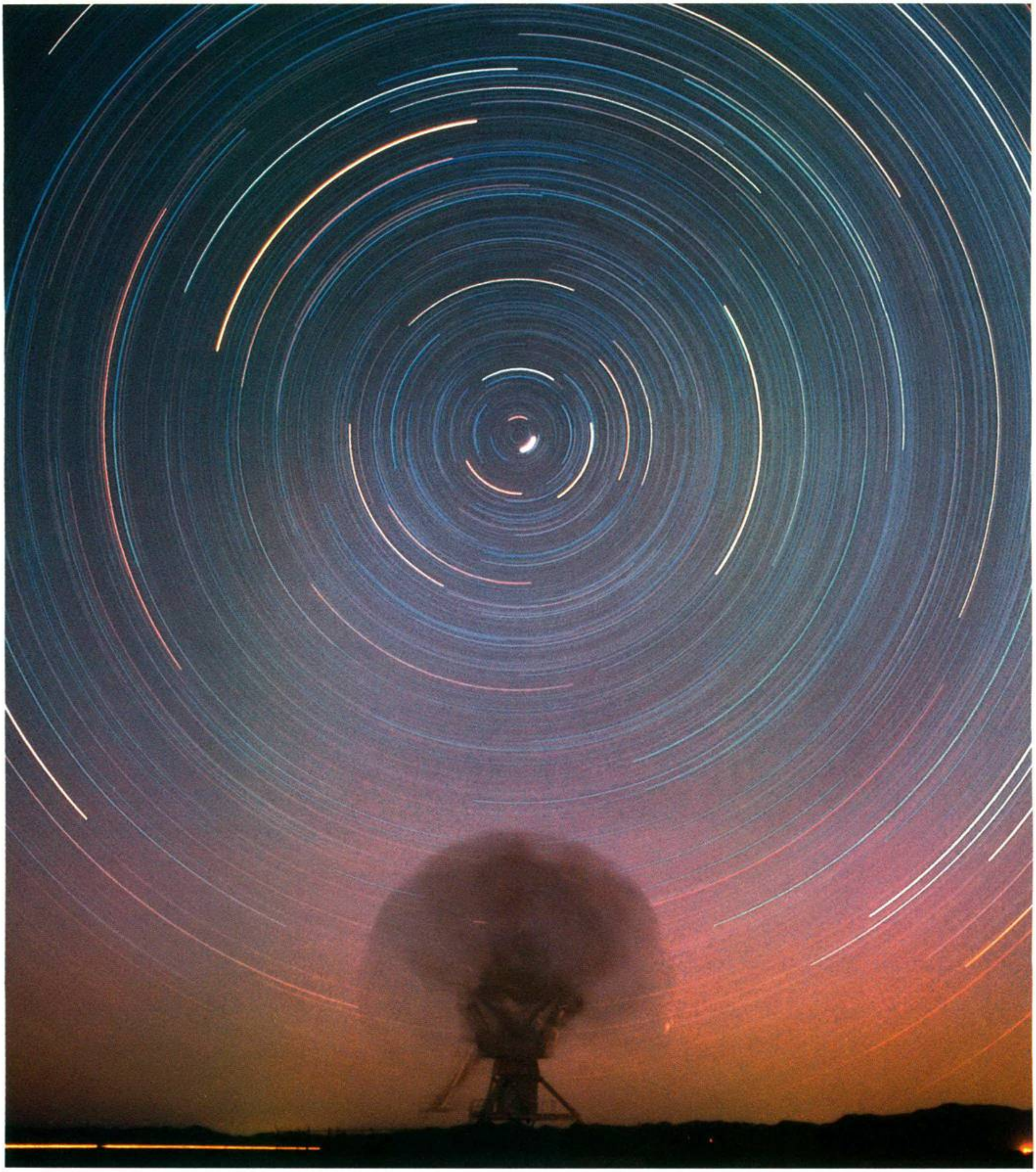


The Moon, Venus, Mars, and Sunflowers

DOUGLAS C. ZUBENEL

(50mm lens, Fuji Super G 800 Plus film, 10-second exposure taken September 9, 1996; the sunflowers were illuminated with a flash at the end of the exposure)

This month's best astrophoto



Stars Trail over the Very Large Array

JOSHUA VAUGHAN

(24mm lens at f/4, Fuji Arista 100 film, 5-hour exposure) Made famous recently by its appearance in the motion picture *Contact*, the Very Large Array radio telescope near Socorro, New Mexico, captures radio energy from galaxies and objects in the Milky Way. During this long exposure the single antenna visible was redirected to another part of the sky, blurring it into an odd shape.

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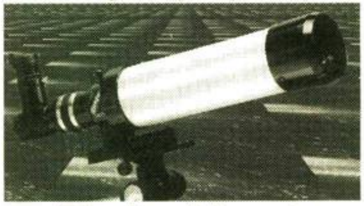

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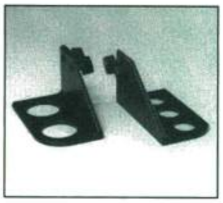

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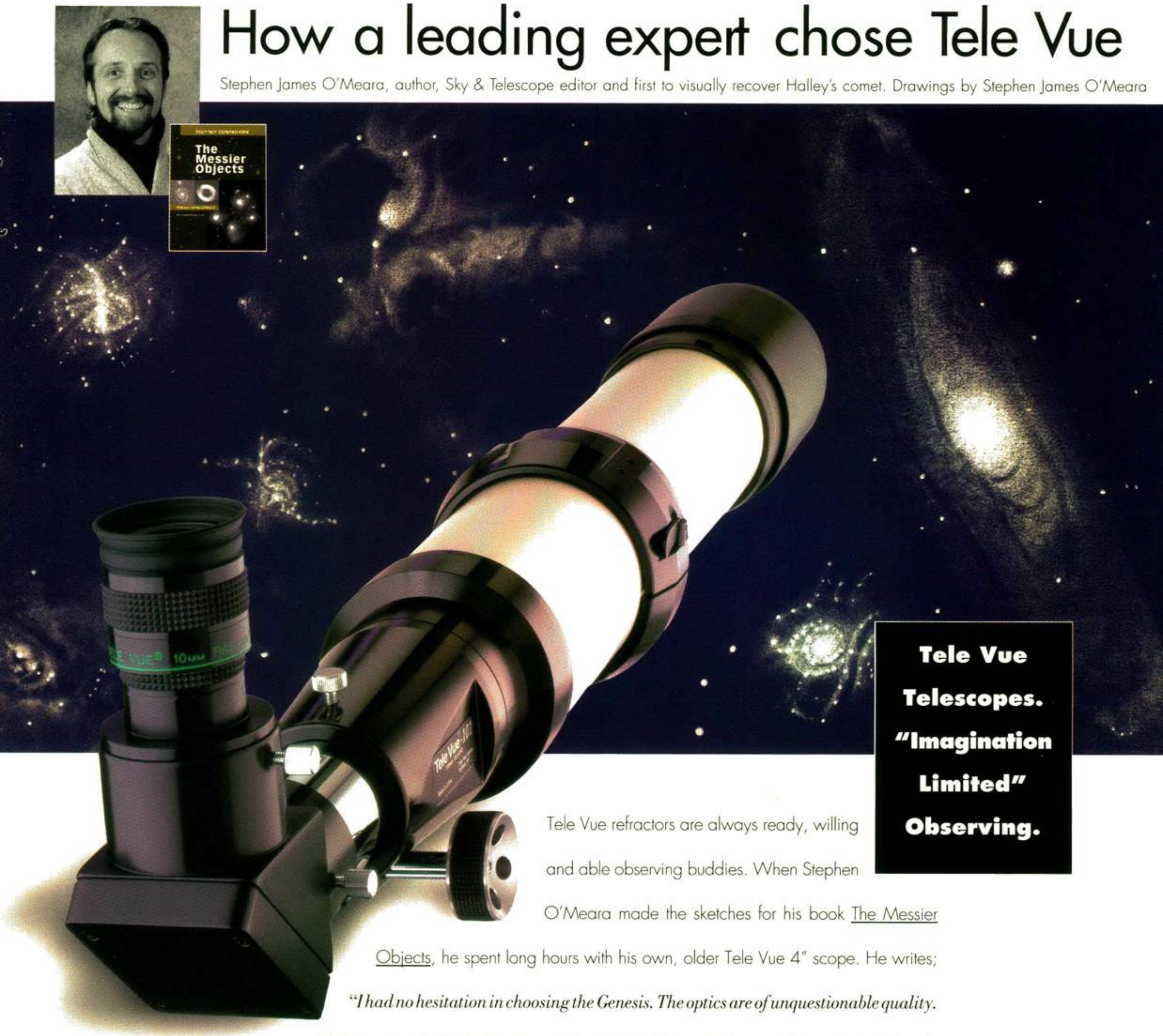

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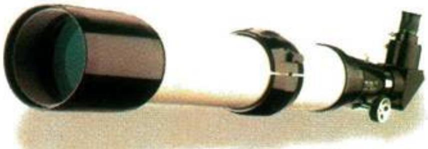
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Images by Jack Newton with the Meade 16" LX200 Schmidt-Cassegrain telescope, Meade f/6.3 Focal Reducer, and Meade Pictor 1616XT CCD Imaging Camera. *Clockwise from lower-left:* the Whirlpool Galaxy (M51); the Eagle Nebula (M16); Spiral Galaxy (M101) in Ursa Major; all exposure times: 5-mins. red, 20-mins. green, 40-mins. blue. The Dumbbell Nebula (M27); exposure times: 5-mins. red, 20-mins. green, 20-mins. blue.

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